INDIANAPOLIS
JAN 13 1905
PUBLIC LIBRARY

THE

AMERICAN NATURALIST.

VOL. XXXVIII. *November–December, 1904.* NOS. 455–456.

THE EMBRYOLOGICAL DEVELOPMENT OF THE SKELETON OF THE HEAD OF BLATTA.[1]

WILLIAM A. RILEY.

OUR knowledge of the embryological development of the sclerites of the head of insects is very meager. With but few exceptions the subject has been treated in the most incidental manner and the observations are few and scattered. This is due not only to the fact that attention has been directed to the more general features of insect embryology, but is due also to a lack of systematizing of our knowledge of the structure of the head of the adult insect and to the difficulty of determining the limits of the sclerites before they become firmly chitinized.

Of all the students of insect embryology, Heymons ('95 and '97), Janet ('99), and Comstock and Kochi, (:02), are the ones who have devoted the most attention to this subject and these workers differ radically in their conclusions.

It was in hopes of determining the conditions in one of the more generalized of the pterygote insects that I undertook the study of the embryological development of the skeleton of the

[1]Contribution from the Entomological Laboratory of Cornell University.

head of *Blatta germanica*. This was proposed by Prof. Comstock and to him I am indebted for many suggestions.

In the choice of an object for this study I was guided by the desire to select one of the more generalized forms and one which at the same time would afford an abundance of material. Both of these conditions seemed to be met by *Blatta germanica*. Though undoubtedly highly specialized in some respects, the cockroach is regarded by many students as the most primitive of our pterygote insects. I believe that in this respect one of the Plecoptera would have been more valuable, but as regards abundance of available material it would be difficult to select a form more satisfactory than is Blatta.

On the other hand, as objects of study the embryo of Blatta present certain difficulties which are accentuated in the course of the work. Of these there are "die ausserordentlichen technischen Schwierigkeiten" which Cholodkowsky has so emphasized. These are due primarily to the great mass of yolk, which becomes so brittle as to make it almost impossible to secure complete series of sections by ordinary methods. A more serious difficulty in the work under consideration was the small size of the cells and the indistinctness of the invaginations of the body wall. Of the latter, Wheeler ('89, p. 349) says: "In *Blatta* the formation of the nervous system in its earlier stages cannot be clearly seen from the exterior. The same holds true of the small tracheal invaginations, though several pairs, especially those of the thorax and basal abdominal rings, may be seen on the pluræ in good preparations before revolution. Still they are so much less distinct than in *Doryphora* that I have given them little attention."

THE PRIMITIVE SEGMENTS OF THE HEAD.

The question of the number of segments in the body of the perfect insect early attracted the attention of entomotomists. As the history of the development of our knowledge of the number entering into the structure of the head has been very fully discussed by Comstock and Kochi (:02), I have but little to add to their account.

As early as 1839, Newport discussed this question in considerable detail. He believed in the "correctness of the opinions advanced by Savigny and others, that the organs of manduction are the properly articulated members of distinct segments and are perfectly analogous to the proper organs of locomotion." He attributed the conflict of views to a "too exclusive examination of the head in perfect insects, without reference to the corresponding parts in the larva."

It was thus early realized that it is to the ontogenetic record that we must appeal for a settlement of the question. Unfortunately Newport chose as the basis of his study the larva of *Musca vomitoria*, a form so highly specialized as to be worthless for this purpose. His evidence regarding the possible presence of a fifth segment must therefore be rejected. The value of his conclusion that there were at least four segments was due to his acceptance of the criterion proposed by Savigny.

Zaddach ('54), believed that six segments entered into the composition of the head. Of these the first was the ocular, while the third was the second antennal segment. His evidence regarding the presence of the latter, however, was based upon the erroneous conclusion that in the phryganids the larval antennæ represented the second pair of the Crustacea, and that they were later replaced by the definitive antennæ of the adult, which corresponded to the antennules of the Crustacea.

In 1858 Huxley also discussed the mooted question from the view point of embryology. With characteristic thoroughness and penetration he not only treated of the embryology of an insect, Aphis, but compared its development with that of Crustacea and Arachnida. Granting that the presence of paired appendages was indicative of an equal number of segments, he argues that the absence of the appendages does not necessarily imply the absence of the segment. "No one will pretend that it is so in the abdominal and thoracic regions." In conclusion he proposes the hypothesis "that in the Articulata the head is normally composed of six somites, which are all fully developed only in Podopthalmia, Stomapoda, and some Branchiopoda, while in other Crustacea some one or more of the preoral somites is more or less abortive, and in Arachnida and Insecta the

appendages of the first somite are sessile and those of the second or third undeveloped."

I shall have occasion to revert to this paper of Huxley's, for, as we shall see, he devoted considerable attention to a consideration of the development of the head, and brought out some facts of prime importance.

Packard ('66), believed that the insectean head was composed of seven segments. In 1870, in the second edition of the *Guide to the Study of Insects*, he gives a table of these segments and their appendages. He believed the segments to be a *first ocellary*, *second ocellary*, *opthalmic*, *antennary*, *mandibular*, *first maxillary*, and a *second maxillary* or *labial*. In addition to these seven he includes a hypothetical first segment whose tergal parts give rise to the labrum, epipharynx, and clypeus.[1] Thus at this time he regarded the insectean head as composed of eight primary segments.

In 1871, however, Packard presents evidence to show that the ocelli and the compound eyes do not represent appendages. "Accordingly," he says, "we seem forced to the belief that the head of the hexapodous insect consists of but four segments, *i. e.*, the second maxillary, the first maxillary, and mandibular segments behind the mouth opening and the antennary, or first and preoral segment situated in front of the mouth." This view he reiterates in 1883. In 1898 he tabulates six segments.

One of the most recent workers to approach this subject is Janet ('99). Basing his conclusions largely on a study of the musculature of the adult Vespa, this worker states that the so-called primary head segment — the protocerebral segment of authors — is in reality composed of four segments and that therefore the head of an insect is made up of not less than *nine* segments, all of which were primitively postoral. According to Janet these segments are:

1°	Le somite du gésier	ou	somite proto-stomodæal
2°	Le somite œsophagien	ou	somite deuto-stomodæal
3°	Le somite clypéo-pharyngien	ou	somite trito-stomodæal

[1] "The tergal parts (*i. e.*, the labrum, epipharynx, and clypeus) situated in front of the ocelli, are left out in enumerating the seven segments as they are not supposed by the author to belong to either of those segments." *L. c.* p. 20.

4°	Le somite du labre	ou	somite proto-cérébral
5°	Le somite antennaire	ou	somite deuto-cérébral
6°	Le somite post-antennaire	ou	somite trito-cérébral
7°	Le somite mandibulaire	ou	somite proto-gnathal
8°	Le somite maxillaire	ou	somite deuto-gnathal
9°	Le somite labial	ou	somite trito-gnathal

From the embryological view point Janet sees support for these conclusions in the development of the sympathetic nervous system. He considers "the nervous system of the stomodæum (or the unpaired sympathetic system) as being simply the morphological prolongation on the ectodermic stomodæal invagination, of the chain of the central system." The untenability of this view has been pointed out by Heymons, (:00), who has devoted especial attention to the study of the development of the sympathetic system, and whose argument, therefore, carries especial weight.

Of the work of Patten, Wheeler, Viallanes and Folsom, the excellent résumé by Comstock and Kochi leaves little to be said. These last writers accept Folsom's conclusion as to the presence of seven primitive segments, and agree with him that the appendages of the superlingual segment may be represented in the Orthoptera by a pair of small sclerites lying behind the lingua, within the mouth cavity. Neither Heymons nor Wheeler[1] accept this view. As regards the condition in the cockroach, I have only the negative evidence that there is wholly lacking a trace of a ganglion belonging to this segment. The position of the above mentioned sclerites is such as to make them readily susceptible of explanation on purely mechanical grounds, as secondary structures. Though Folsom's work was done on Anurida, and his corroborative evidence was drawn from a study of other Collembola, it is not to be expected that we should find such a fundamental difference between the Apterygota and the Pterygota.

[1] In a forthcoming paper, which Dr. Wheeler has kindly allowed me to anticipate by the above statement, he very fully and conclusively presents the arguments against such a view.

THE GENERAL FEATURES OF THE FORMATION OF THE HEAD OF BLATTA.

The changes during the first six days[1] of the embryonic life of Blatta lead to the formation of the ventral plate, the blastodermic thickening which represents the first rudiment of the germ band. This extends along about two-thirds of the ventral surface of the egg, beginning at about one-fourth of the length of the egg from its cephalic end.

The newly formed germ band is not an evenly developed structure, but there are to be seen, on each side, groups of rapidly proliferating cells. These active cells give rise to an indistinct segmentation in the earlier stages of the germ band. This was noted by Cholodkowsky ('89), who says, (p. 91): "However, when I say that the young germ band of Blatta gives no indication of cross divisions I do not mean by that that there are no traces of metamerism. Very early when the germ band is still very imperfectly marked off from the surrounding undifferentiated blastoderm, one may observe a noteworthy grouping of its cells around certain points which are none other than the centers for the formation of the future appendages."

Heymons ('95), has correctly interpreted this description of Cholodkowsky's as referring to certain formative centers in the undifferentiated blastoderm, which by their extension and fusion give rise to the germ band. A similar method of formation of the germ band of Astacus had already been pointed out by Reichenbach ('86). That Cholodkowsky was not clear as to the nature of these centers is evident not only from his reference to them as the precursors of the appendages, but also from his Figure 2, which shows an embryo of about ten days, in which the mouth parts and thoracic appendages are already prominent, while there is to be seen "die beginnende Gruppirung der Zellen für die Anlagen des ersten Paares von Abdominalfüssen."

[1] Cholodkowsky ('91), states that on account of the peculiarity of ovoposition, the age of the embryos of Blatta is not easily determined. As an illustration of this, I have found that there may be considerable variation in the degree of development of the embryos of a single capsule. However, the few observations I have made have, in the main, confirmed Wheeler's approximations, and I have followed him in determining the ages of the embryos studied.

An interesting fact is that, as pointed out by Heymons ('95b), the cephalic lobes arise from three pairs of these centers of proliferation, which very early fuse. Wheeler found that two such centers entered into the formation of the lobes of Xiphidium. The presence of the three pairs would preclude Cholodkowsky's idea that these centers represent future appendages. On first thought it might seem that their presence confirms Janet's view as to the compound nature of the preoral region. Janet believes, however, that there are three segments lying cephalad of the cephalic lobes, and that these do not fuse with the lobes, but in the later stages are invaginated with the stomodæum. It is evident that the formative centers of the cephalic lobes lend no support to that view. It has been suggested that they might represent the three segments whose ganglia enter into the formation of the brain. That this is not the case is shown from the fact that these areas precede the definite formation of the germ band, and that their fusion and consequent obliteration has taken place long before the deuto- and tritocerebral segments have united with the protocerebral segment.

It is during the seventh day, after the appearance of the blastoporic thickening of the caudal end, that there becomes prominent a pair of thickenings laterally placed at the cephalic end of the germ band (Fig. 1, *c. l.*). These thickenings represent the cephalic lobes, which are destined to play a most important rôle in the formation of the head capsule. From the first they are connected with the germ band. Of an independent development, such as described by Will ('88) for Aphis and by Heider ('89) for Hydrophilus, I find no indication in Blatta.

FIG. 1.—The germ band of seventh day. The cephalic lobes (*c. l.*) are indicated. × 120.

During the eighth day of embryonic life the most striking change is the appearance and very rapid development of the amnio-serosal folds,—phenomena which have been described in detail by Wheeler. The cephalic lobes develop rapidly, and during the first half of the ninth day they become prominently demarcated from the strap-like trunk region. The embryo in this stage covers about half of the ventral face of the egg, being somewhat

nearer to the cephalic than to the caudal end. In such an embryo, measuring 1.4 mm. in length, the lobes were .33 mm., about one-fourth of the entire length. Their breadth was .38 mm., compared with .24 mm. for that of the trunk region.

It is during this period that the antennæ appear. These, the earliest of the appendages, are in their origin post-oral. Though generally credited to Weismann, it was Zaddach ('54) who first pointed out this fact. Since that time many workers have confirmed the statement of Zaddach, but more recently it has been seriously questioned. Since the point is one of considerable importance in a determination of the origin of the sclerites, it is necessary to devote especial attention to it in this place.

Viallanes is especially pronounced in his opposition to the interpretation of the antennæ as originally post-oral. In '91, speaking of the 3rd stage in the development of Mantis, he says:

"Les antennes sont encore actuellement les seuls membres en voie de formation, elles apparaissent comme des mamelons à droite et à gauche de la bouche, mais non en arrière de celles-ci. Si au lieu de nous contenter d'examiner un embryon par transparence, nous l'examinons par réflexion, ce qui permet d'en apprécier bien plus exactement le relief, nous constaterons que les mamelons antennaires sont réunis l'un à l'autre par un bourrelet saillant passant en avant de la bouche. Ce bourrelet est fortement incurvé et sa concavité dirigée en arrière embrasse l'orifice buccal. Si nous supposions redressé ce bourrelet aux extrémités duquel se voient les mamelons antennaires, ceux-ci deviendraient nettement prébuccaux. Cette constatation ne nous donne-t-elle pas lieu de penser que les antennes, bien qu'elles apparaissent au niveau de la bouche (c'est-à-dire dans une région du corps qui ne peut être appelée ni prébuccale ni post-buccale), sont réellement prébuccales, bien que déviées de leur situation originelle par suite du développement excessif des lobes procéphaliques?" (p. 288.)

Later, concerning the 5th stage, he says: "Les mamelons antennaires ont grandi; par suite de l'accroissement des lobes procéphaliques ils sont rejetés en arrière et leur situation est devenue nettement post-buccale. C'est l'examen d'états ana-

logues à celui que nous décrivons maintenant qui a décidé la plupart des embryologistes à considérer, à tort croyons-nous, l'antenne comme un membre post-buccal." (p. 289.)

Viallanes was influenced in his interpretation by his studies of the nervous system of the adult, in which the deutocerebrum, the ganglion of the antennal segment, is clearly pre-oral, as is also its commissure.

More recently, Comstock and Kochi (: 02) have challenged the commonly accepted view. Believing that the clypeus "represents the median field of the sternite of the antennal segment," they argue that a study of the figures given by authors describing a post-oral position of these appendages "shows that while a line connecting the two antennæ would pass in some cases behind the mouth it is by no means so clear that the basal part of the rudiment of the antennal sclerite does not abut against the procephalon. In fact, the very figures given to support the view that the antennæ are post-oral in the early embryo support the opposite view." (p. 31.)

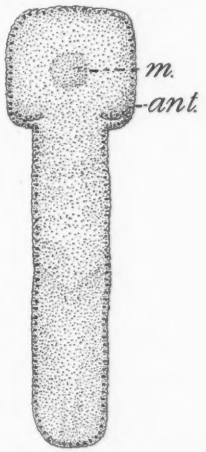


FIG. 2. — The ventral aspect of an embryo of about nine days. The antennæ (*ant.*) have just appeared, while the stomodæum (*m.*) is but indicated by a slight thickening of the cells. × 501.

A study of Blatta has served to confirm the view of Zaddach. At the time of the first appearance of the antennæ the stomodæal invagination has not yet manifested itself. Its position is marked, however, by an area of rapidly proliferating cells (Fig. 2, *m.*). The antennal rudiments are clearly caudad of this area, and are thus at their earliest appearance post-oral (Fig. 2, *ant.*). They increase rapidly in size, and at a stage but slightly later than that represented in Fig. 2, they lie caudo-laterad of the newly formed stomodæum. It is at this stage that they were studied by Viallanes. Very soon they are pushed more markedly post-orally, and it is in this stage that they have usually been figured (Fig. 3, *ant.*).

From the view point of comparative anatomy we have in Apus strong evidence of the original post-oral position of the antennæ.

Lankester thought that in this form the antennæ of the adult were innervated from subœsophageal ganglia. Though this has proven to be incorrect, Pelseneer ('85) has shown that the antennal ganglia of the adult, though associated with, are histologically perfectly distinct from those of the archicerebrum, and that they are perfectly homologous with the ganglia of the ventral cord.

FIG. 3.— Embryo late in the tenth day. The antennæ lie laterad of the stomodæal opening. The procephalon (*pr.*) lies cephalad of the opening. Between the antennæ (*ant.*) and the mandibles (*md.*) lie the second antennæ (*2d ant.*). × 80.

By the end of the ninth day there are to be seen, in addition to the antennal rudiments, those of the thoracic appendages, which are distinctly outlined, while those of the mouth-parts are merely indicated. This is the stage figured by Wheeler ('89, Fig. 44). Wheeler found that in many embryos, as in the one which he figures, "one or, more rarely, both antennary lobes are temporarily bilobed." This he thought might be due to a temporary reversion, 'tending to show that the antennary lobes originally gave rise to two pairs of appendages which were perhaps homologous with the two pairs of antennæ in the Crustacea.' In embryos but slightly more advanced I, also, have seen indications of this bilobulation. Believing that the antennæ of insects are not to be homologized with those of the annelids but, rather, are homodynamous with the other appendages, I should regard this temporarily bilobed condition as a possible reversion toward a biramous condition of the appendage.

The next notable change is the appearance, during the tenth day, of the mouth and of the rudiment of the procephalon. The mouth is not invaginated from within the latter, but, as is shown by Figure 3, lies caudad of it.

There has been much discussion concerning the origin of this rudiment of the procephalon which, by many, is spoken of as merely that of the labrum. A number of observers have reported that in certain forms it originates as a paired structure (Hydrophilus, Kowalevsky, '71, Heider, '89, Graber, '90; *Bombyx mori*, Tichomiroff, '82; Pieris, Gastropacha, Zygæna, Graber,

'90; Hyalotoma, Graber, '90; Chalicodoma, Carrière, '90, Bürger, '97). Kowalevsky, Patten, Carrière, and others maintain that not only does this structure arise from paired rudiments, but that it represents a fused pair of appendages. Bürger in his edition of Carrière's notes, does not commit himself to the latter view.

On the other hand a greater number of species have been noted in which the procephalon is, from the first, unpaired. Among these are included a number of Apterygota (see Folsom, :00, pp. 93–96), while of the Pterygota may be mentioned Aphis (Huxley, '58); Apis (Grassi, '84); Œcanthus (Ayers, '84); Forficula (Heymons, '95); Mantis (Viallanes, '91); Blatta (Cholodkowsky, '90); *et al.* Heymons has emphasized the fact that the place of origin of the labrum, *between* the two halves of the nervous system rather than laterad of them, fundamentally distinguishes this structure from the true appendages.

Especial attention was directed to this point in Blatta on account of finding an embryo in which the procephalon was quite clearly in two distinct halves. A study of a large number of other preparations of the same stage failed to duplicate this, though in some there was to be seen a slight mesal constriction. As the embryo first mentioned was otherwise distorted I am inclined to regard the appearance of the procephalon as abnormal, and to agree with Cholodkowsky that in Blatta its rudiment is unpaired.

By the end of the tenth day the embryo has increased considerably in length, and the mouth part appendages are all distinct. In an embryo of 1.5 mm. length, the ocular and antennal segments, which at this time constitute the head of the embryo, measured 275 μ, while the mouth part region was 350 μ in length, their relative extent being thus as 11 : 14. The 1st and 2nd maxillæ are subequal and have relatively the same situation upon the germ band. The mandibles are considerably smaller, but are equally distinct (Fig. 4).

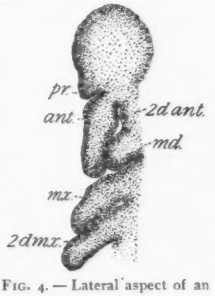


FIG. 4. — Lateral aspect of an embryo a little older than the preceding. × 80.

A striking feature of embryos of this period is the relation

of the mandibles to the antennæ. They are separated by a space much greater than that which separates the mandibles from the 1st maxillæ. This appearance, which in Hydrophilus proved so puzzling to Heider, is due to the presence of the so-called "intercalary," "Vorkiefer," "premandibular," or "tritocerebral" segment. As the evidence all tends to show that this segment is the homologue of the second antennal segment of the Crustacea, it should be designated either so or as the *tritocerebral* segment rather than by the indefinite and non-committal term "premandibular."

Wheeler ('93) was the first to demonstrate in Anurida a pair of vestigial appendages, which bear to its ganglion the same relation as do the other appendages to the ganglia of their respective segments. Wheeler's work has been abundantly confirmed by workers on the embryology of the Apterygota, Uzel ('98) and Folsom ('99) having determined that in certain forms these appendages persist even to the adult stage.

Though these results have been generally accepted as applying to the Apterygota, embryologists have been unwilling to accept the scant evidence of the presence of such vestigial appendages in the Pterygota. As long ago as 1870 Bütschli observed in the embryo of Apis a paired rudiment just behind the mouth, which, as he said, "sich fast wie ein Paar innerer Antennen ausnimmt." Bütschli himself did not regard this structure as homologous with the other appendages. Grassi ('84) also noted these appendages, but contrary to Bütschli, who thought that they fused to form a transitory under lip, Grassi states that they quickly disappear without leaving a trace. Moreover, he went farther than Bütschli in comparing them to antennæ, for, as Heider has pointed out, he says, "Il primo paio d'arti boccali, che ha un'esistenza effimera, può forse paragonarsi ad un paio d'antenne degli artrapode" (p. 57). Carrière ('90) described similar rudiments for Chalicodoma, and his statements were verified by Bürger ('97). On the whole, however, insect embryologists discard the above evidence and agree with Heymons ('95 b) who says of the tritocerebral segment, "Sein rudimentär Charakter gibt sich hauptsächlich darin zu erkennen, dass sich an ihm niemals Extremitäten entwickeln. Dies gibt wenigstens, so weit wir bisher wissen, von den pterygoten Insecten."

In the face of these opinions it may seem somewhat venturesome to assert that in Blatta there are evidences of the presence of such appendages. And yet, I believe that the facts warrant this conclusion. In embryos of the eleventh day, in favorable specimens there are to be seen between the antennal and the mandibular rudiments, in the region occupied by the tritocerebral ganglion, small but distinct thickenings of the hypodermis (Fig. 4, *2nd ant.*). Moreover, these are to be detected in both cross and longitudinal sections (Fig. 5), and bear to the ganglion of the tritocerebral segment the same relation which we should expect of appendages. To be sure, not every hypodermal thickening is to be interpreted as the rudiment of an appendage. Since, however, the thickenings under consideration occur not only in one but in several preparations, since they occur in the location we should expect for such appendages and do not occur between the other pairs of appendages, and since, lastly, they bear the expected relation to the ganglia of the second antennal segment, I see no other interpretation than that they represent vestiges of appendages such as are still developed in some of the apterygote insects.

FIG. 5. — Longisection of an embryo of eleven days. × 106.

The mouth-part appendages rapidly increase in size, and early in the eleventh day the length of the 1st maxillæ considerably exceeds that of the second maxillæ, while a little earlier these appendages were subequal. Measuring from the caudal angle to the apex, we find the length of the mandibles to be about 55 μ, that of the 1st maxillæ 96 μ, while the 2nd maxillæ are but 70 μ. There is no trace of lobulation in any of the mouth parts.

The procephalic rudiment has become prominent and, in the latter part of the eleventh day, appears as a button-shaped swelling overlying the mouth. In surface views the mouth can be seen through the rudiment, lying slightly caudad of its center. It is this appearance which has led to the incorrect statement that the mouth develops *in* the procephalon. In embryos of

this age it will be seen that the antennæ are migrating forward. They have increased in length so as to almost completely overlie the mandibles.

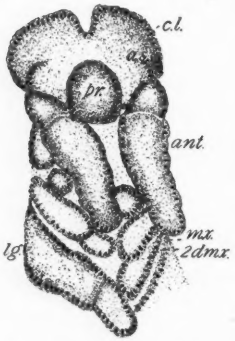


FIG. 6.—Embryo of about thirteen days showing antennal sclerites (*a. s.*) × 80.

The procephalon increases rapidly in size and pushes caudad over the mouth and between the antennæ. In many specimens there is to be noted a constriction of its caudal portion, while the mesal notch of the caudal margin is also distinct.

Early in the twelfth day are to be seen signs of the lobulation of the 1st and 2nd maxillæ. I find no indication of the lobes of these appendages arising from separate, isolated centers, as Heymons ('95a) has described.

It has been stated that the mandibles of Blatta are always simple. I was interested to find that in a few embryos of twelve to thirteen days they appear to be feebly trilobed. This agrees with the condition in Œcanthus, as described by Ayers (p. 24). Korotneff ('81) also represents the mandibles of Gryllotalpa as feebly trilobed (see his Fig. 6), though he says nothing about it in the text.

FIG. 7.—2nd maxilla of embryo of about thirteen days, showing lobulation. × 120.

Throughout the series it is evident that there is not a perfect fusion of the antennæ with the cephalic lobes, but the point of origin of these appendages is separated from the lobes by a constriction which demarcates a more or less definite area of attachment for the antennæ. This may be seen in Figure 6.

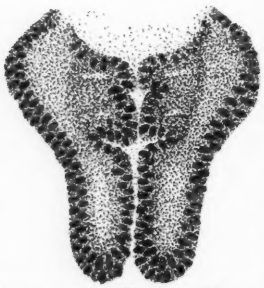


FIG. 8.—2nd maxillæ of an older embryo (about fifteen days) showing the mesad migration. × 120.

The lobulation of the 2nd maxillæ is well shown by Figure 7, which shows one of these appendages from an embryo about thirteen days old. Their mesad migration proceeds rather slowly, until during the fifteenth day they present the appear-

ance shown in Figure 8. They have not yet fused, but the future labrum is clearly outlined. In the meantime they have also migrated forward, so that the space which formerly separated them from the 1st maxillæ has been considerably reduced, and in lateral view the 2nd maxillæ are more or less hidden by the first pair.

About this time there appears a prominent invagination lying cephalo-mesad of the base of the mandible, close to the mandibular ganglion. This lies under the antennæ, but can be seen by focusing below that appendage or by removing it (Fig. 9, *a.t.*). In the same embryos there are prominent ten pairs of tracheal invaginations on the pluræ of the meso-, and metathorax and the first eight abdominal segments. For the prothorax there is a pair of slight and indistinct invaginations which have escaped the attention of previous workers on Blatta. It should be noted that the location of the above mentioned mandibular invaginations is in no wise comparable to that of the tracheæ. In addition to these invaginations there are in the mouth-part region three other pairs — one pair at the cephalo-lateral angle of the mandibles, one between the mandibles and the maxillæ, close to the caudo-lateral angle of the mandibles, and one cephalo-laterad of the base of the 2nd maxillæ. The last pair of invaginations is difficult to detect, for they are smaller, their lumen is not prominent and is frequently hidden by the caudal margin of the 1st maxillæ. It is shown in Figure 10, *p. t.* The invaginations lying laterad of the mandibles form tendons for the mandibular muscles. The rôle of the first and the last pairs in the formation of the tentorium or endoskeleton of the head will be discussed later.

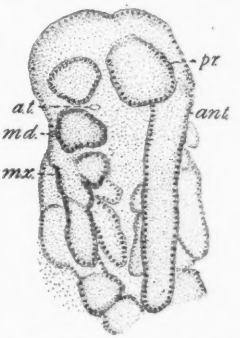


FIG. 9. — Embryo of about fourteen days with right antenna removed, showing the location of the anterior tentorial invagination (*a. t.*) × 80.

Up to this period the length of the mouth-part region has considerably exceeded that of the combined ocular and antennal segments. Thus, as we have seen, in an embryo of about eleven

days the latter region measured 275 μ in length as compared with 350 μ for the mouth-part region. In an embryo at the close of the twelfth day the antennæ have moved forward until the anterior section measures but 200 μ. The mouth-part region, owing to the loss of the tritocerebral segment and the reduction also taking place in the 2nd maxillary segment, measures 280 μ. A comparison early in the fourteenth day shows that the two regions are approximately equal in length. This, as we should suppose from the above, is due not so much to an increase in the size of the anterior region, as to a reduction of the mouth-part region, due to the cephalad migration of the mouth parts. The developing pronotum of the prothorax is pushing rapidly forward, and is limiting the pleural region of the maxillary segments (Fig. 10, *pn.*).

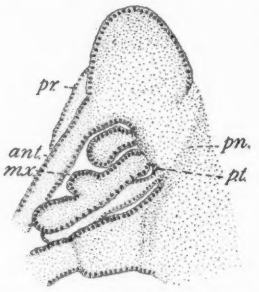


FIG. 10. — Embryo of about sixteen days, showing posterior tentorial invagination (*p. t.*) and the reduction of the mouthpart region. The pronotum (*pr.*) has pushed forward until its anterior margin lies over the first maxilla. × 53.

During the sixteenth day there occurs the series of changes which Wheeler ('89) has described as the revolution of the embryo. This is a period of very rapid growth, and at its close there has been completed the circumcrescence of the yolk by the embryo.

At about the beginning of the sixteenth day, just as these changes have commenced, the conditions do not differ markedly from what I have just described.

The reduction of the mouth-part region is rapidly progressing, the length of the anterior measuring 200 μ as compared with 160 μ for the mouth-part region. The pleural region of the prothorax has extended forward until its most cephalic point lies over the base of the 1st maxillæ, while its indistinct spiracular invagination lies over the base of the 2nd maxilla. The cephalic lobes have extended back until they lie well over the base of the mandibles. The 1st maxillæ greatly exceed the 2nd, which have all but fused to form the labium.

In ventral view of embryos about this age the appendages completely hide the sternal region; but on carefully dissecting

away the antennæ and the procephalon, it may be seen that the sternites of the mandibular and 1st maxillary segments have fused, and form a well marked area lying between their respective appendages (Fig. 12, *hyp.*). We shall refer to this again, in the discussion of the development of the sclerites.

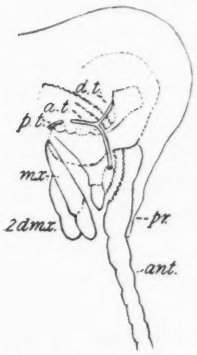


FIG. 11. — Diagram showing the arms to the tentorium in their relation to the nervous system and mouth parts.

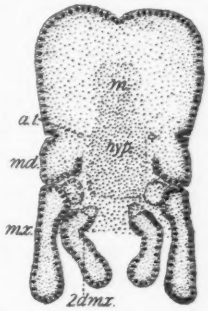


FIG. 12.—Ventral view of embryo of sixteen days. The antennæ and the procephalon have been removed to expose the hypopharynx. × 80.

The procephalon is much enlarged and at its proximal end is wedged in between the cephalic lobes in the manner described by Huxley ('58).

The change which Weismann described as a rotation of the cephalic lobes as upon an axis, occurs during the latter part of the sixteenth and the early part of the seventeenth days. This change is best followed by observing the relations of the brain lobes and of the tendon invaginations to the rest of the cephalic region. At its close the cephalic lobes have pushed over the mandibles in such a way as to crowd back the mandibular pleurites. The mouth parts assume much their definitive position, and the head is practically formed, though it is not until much later that the sclerites have become so chitinized as to be perfectly distinct.

THE DEVELOPMENT OF THE TENTORIUM.

The tentorium or internal skeleton of the head of the adult cockroach has been described and figured by Miall and Denny ('86) and, more fully, by Comstock and Kochi (:02). The latter have treated of its structure in a number of forms, and have shown that its attachments afford valuable criteria for homologizing sclerites in different insects.

In the adult Blatta the body of the tentorium consists of a

chitinous plate underlying the œsophagus and protecting the sub-œsophageal ganglion. From the anterior margin of the body of the tentorium there extends forward a pair of processes, the *anterior arms*, which are attached at the cephalo-lateral angles of the clypeus, near the bases of the mandibles. Corresponding with these are the *posterior arms*, which are near the margin of the occipital foramen, just above the articulation of the maxillæ. In addition there passes up from the body of the tentorium to be inserted at the margins of the antennal sclerites, a third pair of processes, the *dorsal arms*. The entire structure arises from two pairs of ectodermal invaginations.

As early as the thirteenth day there appears cephalo-mesad of the base of the mandibles a prominent pair of invaginations which give rise to the anterior arms (Fig. 9, *a. t.*). These invaginations lie close to the latero-anterior angles of the mandibular ganglion. Heymons refers to the anterior arms in Forficula as originating at the base of the antennæ. In Blatta they are hidden by the antennæ, which must be removed in order to see the invaginations distinctly; but they clearly belong to the mandibular segment.

The invaginations for the posterior arms lie cephalo-laterad of the bases of the 2nd maxillæ (Fig. 10, *p. t.*) They are much less prominent than those of the anterior arms, and, more or less hidden by the 1st maxillæ, they are difficult to detect. They seem to be somewhat retarded in their development, for I have been unable to find them in embryos which clearly showed the invaginations in the mandibular segment.

The invaginations of the anterior arms extend upwards along the sides of the mandibular ganglion, and then, bending at an angle, pass caudo-mesad. At a comparatively late date the two invaginations fuse, and thus give rise to the main body of the tentorium. On the other hand the posterior invaginations pass as blind sacs slightly upward and then forward, to fuse ultimately with the anterior arms.

While the anterior and the posterior arms thus originate as invaginations of the body-wall, the dorsal arms arise, not as invaginations but as processes, from the anterior arms. These processes gradually extend dorsad and thus come into connec-

tion with the body-wall in the region of the antennal sclerites. Figure 11 shows diagrammatically the course of the tentorial arms in an embryo of about eighteen days.

Considering the rapid growth of the embryo during the period following their appearance, the development of these rudiments is but slow. It is not until the twentieth day or later that the fusion of the two pairs of rudiments has taken place.

In view of this method of origin of the dorsal arms of the tentorium of Blatta, it is interesting to note the condition in the Plecoptera, a group in many respects more generalized than the Blattidæ. Of the dorsal arms in these forms Comstock and Kochi, p. 41, say: "In the Plecoptera it appears to be merely a chitinized tendon, the peripheral end of which is less chitinized than the base and is only loosely attached to the skull." Believing that in other insects the anterior arms arise from a distinct invagination, these authors continue: "It remains to be determined whether or not the dorsal arms in the Plecoptera are homologous with the apodeme-like dorsal arms in other insects and, if so, which type is the more generalized." As has been seen, the evidence of embryology shows that the generalized condition is that which still persists in the Plecoptera.

The most thorough study of the development of the tentorium was that of Heider ('89). In addition to this investigator, several others have devoted more or less attention to the subject. Hatschek ('77) called attention to what he supposed were tracheal invaginations in the head of lepidopterous embryos. Tichomiroff ('79) says: "There exists no head tracheæ such as Hatschek thought he discovered. The epithelial invaginations here found I believe to be the rudiments of the inner head-skeleton." Ayers ('84) noticed invaginations in the head region, but was unable to determine their rôle. He inclined to the belief that they disappear altogether, "as no trace of them was to be found in sections of an embryo about the time of hatching." Wheeler ('89) attributed the tentorium to five pairs of invaginations anterior to the maxillary segment.

My results agree with those of Heider, who described the tentorium as arising from two pairs of invaginations, one in the

mandibular and one in the second maxillary segments. Heymons ('95) basing his conclusions mainly on a study of Forficula, described essentially the same conditions, as applying to Forficula and to the Orthoptera, including the Blattidæ. Carrière and Bürger made the same observations on Chalicodoma, thus lending strength to Heymon's surmise that such a mode of origin is typical for the entire group of insects.

Various investigators, among whom are Palmen ('77), Hatschek ('77), Wheeler ('89), and especially Carrière ('90), and Bürger ('97), have regarded the tentorial invaginations as homodynamous with the tracheal invaginations. To this Korschelt and Heider ('93) object that their rudiments do not by any means everywhere agree so closely with tracheal stigmata of the following segments as they do in Chalicodoma. This is especially true of these rudiments in Blatta. As we have seen, the invaginations for the anterior arms arise close to the median line, just laterad of the nerve cord. This corresponds more nearly to the position of the invaginations for the thoracic furca. The origin of the posterior invaginations is more suggestive of the stigmatic invaginations.

In considering this question it must be remembered that Chalicodoma is a highly specialized type with an interpolated larval stage, while Blatta is a representative of a comparatively generalized group of hemimetabolous insects. This being the case, it does not seem that we should regard the location of the tentorial rudiments in Chalicodoma as primitive, but rather I should regard it as secondary. The fact urged by Palman, that the chitinous lining of the tentorium, like that of the tracheæ, is shed during ecdysis, is of little weight, since the same holds true of any hollow ectodermal invagination in insects.

However, it is not necessary to conclude that the tentorial invaginations are metamorphosed tracheæ "which have lost their primitive function and become secondarily modified." If, with Kennel, we derive the tracheæ from dermal glands of annelidan ancestors, there is no reason why we should not consider the tracheæ and the tentorium as homologous structures. Certain of these glands definitely localized have become modified to form tracheæ, while certain others, of the same origin though not

homodynamous with the first, have become converted into the tentorium.

The Development of the Head Sclerites.

As before stated, it is only in the most incidental manner that insect embryologists have touched upon the development of the head sclerites. Before presenting my conclusions concerning the development of the head capsule of Blatta, I shall briefly review the more important of the scattered references, reserving comment until we are ready to compare the views thus expressed with the results of my work.

The earliest of the references was that of Zaddach ('54). This pioneer worker has not received due credit for what he so independently accomplished. Many general features of the embryological development of insects, though credited to much later writers, were clearly outlined by Zaddach. Working altogether with entire mounts, it is but natural that his conclusions regarding the external changes should be the most accurate. It was he who first pointed out the post-oral origin of the antennæ, and called attention to a special antennal segment distinct from the cephalic lobes. He described the procephalon ("*Vorderkopf*"), and derived from it the labrum, the clypeus and the front ("*hinterer und vorderer Kopfschild und Oberlippe*"). He believed that the cephalic lobes formed the bulk of the head capsule, while the Y-shaped suture represented the line of fusion of the cephalic lobes and the procephalon.

Huxley ('58) gave a more accurate description of the procephalon. He also gave a fuller account of the dorsal flexure of the cephalic region, as a consequence of which "the line of attachment of the bases of the eyes and antennæ is frequently altogether above that of the other appendages, so that they appear to be tergal, and not sternal, appendages." The procephalic lobes he regarded as the sternite of the first, or opthalmic, segment and though he does not make a direct statement, the inference is that his "antennulary and antennary sterna" are represented by the labrum and the clypeus.

Packard in his earlier work devoted some attention to the

study of the development of the head sclerites. In 1866 he argued that "since the arthropleural is the limb-bearing region of the thorax it must follow that this region is largely developed in the head," the sternites being reduced to a minimum and the tergites almost completely absorbed. He believed that the bulk of the head is formed "by the great expansions of the eye-pleurites which, so to speak, are drawn back like a hood over the basal rings."

In 1870, in the second edition of his "Guide to the Study of Insects (foot-note)," he reiterates these conclusions. He distinguishes the labrum, epipharynx, and clypeus as tergal elements belonging to his hypothetical pre-ocellary segment. The occiput also is reckoned with the tergites, while the gula is sternal. All of the other elements of the capsule are supposed to be pleural.

Packard later completely revised his views as to the number of primitive head segments. Instead of seven or a possible eight, he recognized but four segments entering into the formation of this region. In 1883, in his paper on "The Number of Segments in the Head of Winged Insects," he thus summarizes his views as to the development of the sclerites:

"It appears, then, that the epicranium or that piece (sclerite) bearing the eyes, ocelli, and antennæ, and in front of the clypeus and labrum, is formed from the original procephalic lobes, and represents the first or antennal segment; while the remainder of the original or primitive segments are obsolete, except in those insects which retain traces of an occiput or fourth cephalic tergite. All of the gular region of the head probably represents the base of the primitive second maxillæ."

Ayers ('83) refers to the reduction of the maxillary and mandibular segments, "their dorsal portions disappearing altogether and their ventral portions fusing with the oral region."

Viallanes ('86 and '87b) states that the head of an insect presents three prebuccal segments and that the labrum represents the sternite of the third or tritocerebral segment. Beyond this he does not enter upon a discussion of the origin of the sclerites.

Heider ('89) was the first to devote especial attention to the development of the tentorium. His careful studies of the origin

of this structure have already been discussed. Regarding the sclerites he states that the labrum and the clypeus arise from the procephalon, while the remainder of the head capsule is formed mainly by the bending over dorsally and the backward extension of the cephalic lobes.

It is Heymons who has devoted the most attention to a study of the embryological development of the head sclerites. Studying mainly the development of various species of the Orthoptera, he very definitely stated his conclusions in his paper on the segmentation of the insect body ('95a). The labrum and the clypeus he derives from the procephalon, while the front, he concludes, is developed from the fused cephalic lobes. The vertex, occiput and genæ he believes are developed from the fused tergites of the mouth part segments, while the hypopharynx arises from the fusion of the sternites of these same three segments.

Janet, '99, finds in the sclerites but little indication of the primitive segments. Thus he finds that the front "appartient, par sa partie antérieure, au somite clypéopharyngien; par sa partie postérieure, au somite du labre; par ses parties latérales, au somite antennaire." Based upon years of study of the morphology of certain Hymenoptera, Janet's paper presents a fund of valuable anatomical data. From the embryological view point it is less satisfactory. Moreover, though recognizing the confusion in the use of terms to designate the head sclerites, Janet has made no attempt to determine homologies. Until this has been carefully done, results obtained from a study of such a group as the Formicoidea can be of but little general application.

On the other hand, Comstock and Kochi, :02, attach very great importance to the relation of the primary segmentation to the sclerites of the adult insect. Their conclusions were based upon comparative anatomical studies of a large series of the more generalized insects, as well as upon embryological data. According to their view, the typical segment is composed of two subsegments. Ventrally the line of union of these subsegments is determined by the position of the furcæ, while laterally it is similarly marked by the position of the lateral apodemes. Between the segments lie the tracheal invaginations, which these

authors regard as homodynamous with the invaginations of the lateral apodemes. Thus to these invaginations of the body wall is ascribed a prime importance in determining the homologies of the sclerites. Another valuable criterion they found in the relations of the appendages to a typical segment.

In addition to limiting and carefully defining the sclerites already generally recognized, Comstock and Kochi also distinguished four pairs of sclerites which had previously escaped attention. These were: 1st, the antennal sclerites bearing the antennæ; 2nd, the antecoxal pieces of the mandibles, a pair of sclerites in some species distinct from the clypeus and forming the ventral articulations of the mandibles; 3rd and 4th, two pairs of maxillary pleurites, narrow, chitinized bands between which articulate the cardines of the maxillæ. In addition to these four pairs of sclerites proper, there are two pairs which may have originally represented segments of appendages. These are: 1st, the ocular sclerites, a pair of annular sclerites bearing the compound eyes, and 2nd, the trochantins of the mandibles, a pair of sclerites between the mandibles and the genæ.

Their conclusions regarding the relations of the head sclerites to the primitive segments and to the appendages were summarized by Comstock and Kochi in the following table:

SEGMENTS	SCLERITES	APPENDAGES
1. Ocular (Protocerebral)	vertex and genæ front	Ocular sclerites
2. Antennal (Deutocerebral)	Antennal sclerites Clypeus proper	Antennæ
3. 2nd Antennal (Tritocerebral)	Labrum (mouth)	2nd Antennæ of Campodea et al
4. Mandibular	Postgenae. Antecoxal pieces Pharyngral sclerites	Mandibles Trochantin

5. Superlingual		Superlingual
	Maxillary pleurites	
6. Maxillary		Maxillæ
	Lingua	
	Lateral cervical sclerites	
7. Labial	Dorsal cervical sclerites	Labium
	Vent. cerv. scl. (gula)	

In each section of the middle column the dotted line indicates the division between the sternal and the lateral elements of the segment.

My results have convinced me that so intimate a relation between primary segmentation and the sclerites cannot be shown.

I find that the front, clypeus, and the labrum are all derived from the procephalon. This is in agreement with the conclusion of Zaddach, '54, whose "hinterer Kopfschild" is clearly the *clypeus posterior* of Newport or the *front* as defined by Comstock and Kochi.

Aside from Zaddach practically all authors agree in stating that from the procephalon arise the clypeus and the labrum. It has been suggested by Comstock and Kochi that the term *clypeus* has thus been used in a broad sense to include both the clypeus anterior and the clypeus posterior or the front.

That Heider used the word clypeus in a yet looser sense is evident. He speaks of the procephalon as giving rise to the clypeus and the labrum. Now, in Hydrophilus, the form upon which he worked, as well as in any of the Hydrophili, the larva does not possess a labrum (Schiodte, '61), or, more correctly speaking, the clypeus and labrum have fused without leaving any line of demarcation between them. Thus Heider has homologized the clypeo-labral sclerite as labrum only, while the front he has mistaken for the entire clypeus.

On the other hand, Heymons, as is shown by his figures, has correctly distinguished the front. Yet he states that the clypeus and labrum arise from the procephalon, while the front is formed from the fused cephalic lobes. He presents no evi-

dence, nor have I been able to find any in support of this view. There remains a consideration of the relation of these sclerites to the primitive segmentation. I have called attention to the fact that though Huxley, '58, does not make any definite statement to that effect, the inference is strong that he regarded these sclerites as representing the sternites of three preoral segments. In fact, in referring to the Crustacea, he says that the labrum represents the sternite of the antennary or third somite. Viallanes, who likewise refers the labrum to the sternite of his tritocerebral or third somite, seems to have attributed to these sclerites a similar definite relation to the primary segmentation.

More recently Comstock and Kochi have independently arrived at and very definitely present the view that the front, clypeus, and labrum represent respectively the sternites of the first three segments. In support of this view they lay much weight on Viallane's statement that the labrum is innervated by the tritocerebrum. Since the front bears one or more of the ocelli, it is obviously derived from the first or ocular segment. The intermediate sclerite, or clypeus, would then belong to the second segment. These writers also believe that the position of the antennal rudiments is only apparently post-oral, — that in reality the basal part of the antennal sclerites abuts against the procephalon.

The embryological evidence, however, shows that the procephalon, and thus the sclerites derived from it, — the front, the clypeus and the labrum, — belong to a single segment, the ocular or protocerebral.

I have discussed elsewhere the question of the primitive position of the antennæ, and have shown that in Blatta their rudiments are clearly post-oral at first.

Even if we were to grant that the antennal rudiments are only apparently post-oral, there can be no question as to the primitive location of the second antennæ and the third somite. Yet the hypothesis derives the labrum from the sternite of this segment.

While I should attach great value to the innervation as a criterion for determining the relation of sclerites to segments, I

do not believe that it can be regarded as absolute. At any rate, the evidence against the labrum as the sternite of the third segment completely outweighs this consideration.[1]

The procephalon develops entirely in front of the stomodæal invagination, and is already well outlined before the deutocerebral and tritocerebral ganglia have moved forward. Moreover, as Prof. Comstock suggested, the labrum and the clypeus give no satisfactory evidence of a paired origin. The absence of median sutures in these sclerites might be readily explained by the statement that fusion had taken place at such an early stage as to be complete. But a more serious objection is that if they develop post-orally and migrate to their pre-oral position, there should be a stage in which they are paired. Such a stage does not occur.

In the Orthoptera and in the Pterygota generally, the second antennal segment is so slightly developed and so transient as to have been largely overlooked by investigators, yet in these forms the labrum is usually strongly developed. On the other hand, in the Apterygota, where the second antennal segment is especially well developed, the labrum is comparatively insignificant.

Finally, the sutures separating the front, clypeus, and labrum are developed at a comparatively late period in the development of the procephalon. If these sclerites represented primary segments, we should find them developing from three distinct centers. The fact that the procephalon develops as a single piece shows that the sclerites derived from it are not primary, but are secondarily developed. In fact, they are not constant, but there are many species in which one or more of the sutures is lacking, and thus the number of sclerites reduced.

The vertex, the compound eyes, and with them the ocular sclerites and the genæ, are formed from the fused cephalic lobes and thus, with the front, clypeus and labrum, belong to the ocular or protocerebral segment. The median suture of the epicranium represents the ventral line of fusion of these lobes.

[1] It should be noted that Janet ('99) considers the labral nerves as in reality arising from the protocerebrum. This is more in harmony with the embryological evidence.

The V-shaped epicranial suture in Blatta separates the front from the vertex. It thus represents the line of separation between the cephalic lobes and the procephalon.

Heymons maintains that the front alone is derived from the fused cephalic lobes. The relatively excessive development of these lobes would indicate that they must enter more largely into the structure of the head. More weighty evidence is the fact that the front is separated from the compound eyes by the V-shaped suture. There is, of course, no question that the eyes belong to the first segment and are developed from the cephalic lobes. Moreover, in following through a series of embryos we can trace the manner in which the front develops by the extension of the procephalon into the angle between the fusing lobes. Thus the direction of this suture — an inverted V with the apex continuous with the median suture of the epicranium — is easily explained. Heymons emphasizes his belief that the suture represents the line of separation between the first and second segments. But if that were the case the rounded caudal margins of the cephalic lobes would on fusing present a V-shaped angle whose apex would be directed cephalad rather than caudad, as is really the case.

On first sight it would seem obvious that the genæ belonged to the mandibular segment. Huxley ('78) described the mandibles as articulating with this sclerite. To this, Miall and Denny ('86) take exception. Comstock and Kochi also call attention to the fact that the chief articulation of the mandibles is with the postgenæ rather than with the genæ. In the earlier stages, after the mandibles have moved forward, it appears as though the mandibular pleurites occupied the position of the future genæ. At the time of the rotation of the embryo, however, the cephalic lobes crowd forward over the dorsal end of the mandibular segment, and thus the pleurites are pushed back to occupy the position of the postgenæ.

It is easy to see how, as a result of this process of displacement of the mandibular segment, there should remain a portion to serve as the ventral articulation of the mandible. In the adult Blatta the limits of this remnant are not to be distinguished from the clypeus ; but, as pointed out by Comstock and

Kochi, in Gryllus and in Corydalis there persists a definite sclerite. These authors have shown that this sclerite bears the same relation to the articulation of the mandible as does the antecoxal piece to the coxa of a thoracic leg, and they have therefore called it the *antecoxal piece* of the mandible.

Along the caudal margin of the postgenæ, but cephalad of the invagination for the posterior arm of the tentorium, is a narrow sclerite, which was first pointed out by Comstock and Kochi. Believing that the posterior tentorial invagination belonged to the first maxillary segment and was homodynamous with the invaginations of the thoracic lateral apodemes, these writers named this sclerite the *anterior maxillary pleurite*. A similar narrow sclerite lying parallel with the first, but caudad of the tentorial invagination, they called the *posterior maxillary pleurite*. We have seen that the posterior arm of the tentorium belongs to the labial segment. The position of its opening in the adult insect — almost directly over the cardo of the first maxilla — is due to the cephalo-mesal growth of the paired labial rudiment, as well as to the backward pushing of the maxillæ at the time of rotation. Thus the sclerite lying caudad of this opening belongs, not to the maxillary but to the labial segment, and should be known as the *labial pleurite*. The sclerite lying cephalad of the opening may retain the name of maxillary pleurite.

However, we cannot restrict the maxillary pleurite entirely to this narrow sclerite. There early takes place a fusion of the pleurites of the mouth part region. The position of the posterior tentorial invaginations serves to mark the anterior limits of the labial pleurite, but the extent of the mandibular and the maxillary pleurites can only be judged from the relations of their appendages. In an embryo of about the sixteenth day, as may be seen from Figure 10, the maxillary pleurites exceed in size either of the others. Though the rotation of the embryo results in a displacement of the maxillæ, I do not believe that their pleurites become reduced to the narrow, imperfectly demarcated sclerites which have been designated as the maxillary pleurites.

We have seen that a portion of the deutocerebral segment, bearing the antennæ, is more or less clearly marked off from the remainder of the germ band, even in the earlier stages. I

believe that this persists as the antennal sclerite of Comstock and Kochi. In embryos about ready to emerge these annular sclerites are very clearly marked, and allow of no question as to their equivalence to other sclerites.

There has been much discussion as to the origin and significance of the hypopharynx, though the data have been drawn almost solely from a study of comparative anatomy. Apparently the majority of those who have thus studied it regard it as representing a fused pair of appendages. Vayssiere ('82) who worked upon larval Ephemeridæ, strongly favored this view, though he adds that in order to settle the question studies of a number of representatives of the various orders would be necessary.

Folsom (:00) derives the hypopharynx of Anurida from a median unpaired evagination between the first maxillæ, and two small papillæ between the mandibles. The first gives rise to the lingua, while from the latter are developed the superlinguæ. The superlinguæ Folsom regards as the appendages of a distinct segment, provided with a small ganglion. He brings forward much evidence from comparative anatomy to show that the hypopharynx of Anurida is typical of the Apterygota. Further than that, he attempts to apply the same interpretation to the Pterygota.

The only worker who has devoted any attention to the embryological development of the hypopharynx of the Ptergota is Heymons ('95a). This investigator reached the surprising conclusion that the hypopharynx represents the fused sternites of the mouth part segments. That this interpretation is essentially correct my studies have convinced me. However, I would not attribute to the labial sternite any part in this structure. I believe that the hypopharynx of Blatta represents the fused sternites of the mandibular and first maxillary segments (Fig. 12, *hyp.*), and that of a consequence of the forward migration of the mouth parts these fused sternites have been pushed to within the mouth cavity.

In Blatta, then, the sternite of the labial segment is represented only by the ventral cervical sclerites. It seems to me very clear that Comstock and Kochi are right in regarding the gula of Coleoptera and certain other insects as representing the fused cervical sclerites.

My views in regard to the relations of the sclerites of the adult Blatta to the primitive segments may be summed up in the following table:

SEGMENT	SCLERITES
Protocerebral	Vertex, genæ.
	Front, clypeus and labrum.
Deutocerebral	Antennal sclerites
Tritocerebral	———
Mandibular	Part of post-genæ, trochantins
	Part of hypopharynx
Maxillary	Remainder of post-genæ, maxillary pleurites
	Remainder of hypopharynx
Labial	Labial pleurites; lateral cervical sclerites
	Ventral cervical sclerites

From the above results it would seem that the definitive sclerites can afford us little or no evidence as to the primary segmentation of the insects. This is certainly true of the head sclerites, and I see no reason why it should not apply to other regions of the body. Sclerites originate from mechanical causes, and do not necessarily have any relation to the primary segmentation.

As an illustration might be cited the breaking up of the annular segment into sternite, pleurites and tergite. The circumcrescence of yolk and the consequent formation of the lateral and dorsal portions of the embryo is a process of gradual growth, and there is no demarcation into separate areas. The distinction into sternite, pleurites, and tergite is a secondary process.

More germane is the fact of the origin of the front, clypeus, and labrum from the procephalon. Thus not only these three sclerites but also the vertex and the genæ arise from the one segment, the protocerebral. I have shown, also, that the post-genæ are to be regarded, not as the pleurites of a single segment, but as the fused pleurites of the mandibular and maxillary segments.

I would not depreciate the value of the sclerites as an index to relationship among insects. That they are to a marked

degree constant, and that they may be homologized in the different groups, I believe to be very true. That they are secondary is equally true, and thus evidence drawn from a study of the sclerites of the adult insect is insufficient to determine the primitive segmentation and the related question as to the compound nature of the segments.

BIBLIOGRAPHY.

BRANDT, A.

'69. Beiträge zur Entwicklungsgeschichte der Libelluliden und Hemipteren. Mém. l'Acad. St. Petersb. 7e ser., Tome 13, No. 1, 31 pp., 3 pl.

CARRIÈRE, J.

'90. Die Entwicklung der Mauerbiene. Archiv. f. mikr. Anat., Bd. 35, pp. 141–165.

CARRIÈRE AND BÜRGER.

'97. Die Entwicklungsgeschichte der Mauerbiene. Abhandl. d. k. Leop.-Carol. Deut. Ak. Bd. 49.

CHOLODKOWSKY, N.

'89. Studien zur Entwicklungsgeschichte der Insecten. Zeit. wiss. Zool. Bd. 48, pp. 89–100, Taf. 8.

CHOLODKOWSKY, N.

'91. Die Embryonalentwicklung von Phyllodromia (Blatta) germanica. Mém. l'Acad. St. Petersb. 7e ser., Tome 38, 121 pp., 6 pl.

COMSTOCK, J. H., AND C. KOCHI.

:02. The Skeleton of the Head of Insects. Amer. Nat., vol. 36, pp. 13–45.

FOLSOM, J. W.

'99b. The Segmentation of the Insect Head. Psyche, vol. 8, pp. 391–394.

FOLSOM, J. W.

:00. The Development of the Mouth-Parts of Anurida maritima. Bull. Mus. Comp. Zoöl., vol. 36, pp. 87–157, pls. 1–8.

HAASE, E.

'89. Die Zusammensetzung des Körpers der Schaben. Sitz.-Ber. d. Gesell. naturf. Freunde Berlin. Nr. 6.

HEIDER, K.

'89. Die Embryonalentwicklung von Hydrophilus piceus. Theil 1. Jena.

HEYMONS, R.

'95a. Die Segmentirung des Insectenkörpers. Anhang z. d. Abhandl. königl. preuss. Akad. Wien, 39 pp., 1 pl.

HEYMONS, R.

'95b. Die Embryonalentwicklung von Dermapteren und Orthopteren. 136 pp., 12 pl. Jena.

HUXLEY, T. H.

'58. On the Agamic Reproduction and Morphology of Aphis. Trans. Linn. Soc., vol. 22, pp. 193–236, pls. 36–40.

HUXLEY, T. H.

'78. Manual of the Anatomy of Invertebrate Animals.

JANET, CH.

'99. Essai sur la constitution morphologique de la tête de l'insecte. 74 pp., 7 pls. Paris.

KORSCHELT AND HEIDER.

'93. Lehrbuch der vergleichenden Entwicklung der wirbellosen Thiere. Jena, 1893. Eng. trans., vol. 3, 1899.

LANKESTER, E. RAY.

'81. Appendages and Nervous System of Apus cancriformis. Quar. Jr. Micr. Sci., new ser., vol. 21, pp. 243–376, pl. 20.

MIALL, L. C., AND A. DENNY.

'86. The Cockroach. London.

NEWPORT, G.

'39. Insecta. Todd's Cyclopædia of Anatomy and Physiology.

PACKARD, A. S.

'66. Observations on the development and position of the Hymenoptera, with notes on the morphology of insects. Proc. Boston Soc. Nat. Hist., vol. 10, pp. 279–295.

PACKARD, A. S.

'71. Embryological Studies on Diplax, Perithemis, and Isotoma. Mem. Peabody Acad. Sci., vol. 1, 24 pp., 3 pls.

PACKARD, A. S.

'80. The Number of Segments in the Head of Winged Insects. Amer. Nat., vol. 17, pp. 1134–1138. (Also in 3rd Report U. S. Ent. Com.)

PACKARD, A. S.

'98. Text-Book of Entomology. New York and London.

PELSENEER, P.

'85. Observations on the Nervous System of Apus. Quar. Jr. Micr. Sci., new series, vol. 25, pp. 433–444.

SAVIGNY.

'16. Mémoires sur les animaux sans vertèbres. Paris.

SCHIODTE, J. C.

'61. De Metamorphosi Eleutheratorum Observationes. Copenhagen.

VIALLANES, H.

'86. La morphologie du squelette céphalique des Insectes. Bull. Soc. Phil. 7e ser., tome 10.

VIALLANES, H.

'87a. Études histologiques et organologiques sur les centres nerveaux et les organes des sens des animaux articulés. 4e Mémoire. Ann. sci. nat. 7e ser., tome 2, pp. 5–100.

VIALLANES, H.

'87b. 5e Mémoire. Ann. sci. nat. 7e ser., tome 4, pp. 1–120.

VIALLANES, H.

'91. Sur quelques points l'histoire du développement embryonnaire de la mante religieuse. Ann. sci. nat. 7e ser., tome 11, pp. 283–323, pls. 12–13.

WEISMANN, A.

'63. Die Entwicklung der Dipteren im Ei. Zeit. wiss. Zool. Bd. 13, pp. 107–220.

WHEELER, W. M.

'89. The Embryology of Blatta germanica and Doryphora decemlineata. Jr. Morph., vol. 3, pp. 291–386, pls. 15–21.

WHEELER, W. M.

'93. A Contribution to Insect Embryology. Jr. Morph., vol. 8, pp. 1–160, pls. 1–6.

ZADDACH, G.

'54. Untersuchungen über die Entwickelung und den Bau der Gliederthiere. Heft. 1. Die Entwicklung des Phryganiden-Eies. 138 pp., 5 pls. Berlin.

THE ARBOREAL ANCESTRY OF THE MAMMALIA.

W. D. MATTHEW.

WITHIN the last few years Dollo and Bensley have adduced strong arguments to show that the marsupials are descended from arboreal ancestors, as indicated especially by the traces in modern marsupials of former opposability in the first digit of the manus and pes.[1] The present writer has for some time been of the opinion that this is true not only of marsupials, but of the placentals as well. Our present knowledge of fossil Mammalia and of the course of evolution of the various modern races, enables us to foreshadow with considerable detail the characters of a common ancestral group (homogeneous in adaptive characters, although perhaps embracing certain differences in dentition etc., of very ancient origin) from which all known mammals, excepting the Prototheria, are descended. That there was such a group ancestral to both metatherian and eutherian mammals is, I believe, reasonably certain. The evidence for it is the close uniformity of these Mammalia in general structure in spite of their wide divergence in adaptive specialization, and the invariable approximation towards a central type of each race whose development is known from palaeontology. As a preliminary to further discussion we may point out the characters of this primitive central type.

1.— *Size very small, skull of moderate length, brain case completely enclosed in bone, brain of high type compared with that of reptilia although lower than in the modern mammals.* In every case where we are able to trace the descent of the large modern mammals, we find their direct ancestors successively smaller as we pass backward in time. The horse and camel have been traced back nearly to the beginning of the Tertiary; their ear-

[1] This view was expressed by Huxley in 1880.

liest representatives are no larger than rabbits. Elephants, rhinoceroses, tapirs, every race about whose ancestry anything is known, exhibit a reduction in size corresponding to the distance back through which we have been able to trace them. The large animals of the early Tertiary are in every case early specializations which have left no descendants.

2.— *Molar teeth "bunodont"* i. e., *low crowned, the crowns composed of a few low broad rounded cones, heavily enamel-covered. The molars are tubercular (crushing) teeth, the premolars trenchant (cutting), the canines moderately large (piercing), the incisors small spatulate (nipping) teeth. The teeth were arranged in continuous series, except for slight gaps behind the canines.* The labors of Cope, Osborn and many other palæontologists have amply demonstrated this as the primitive type of dentition among the Mammalia. Whether we accept the whole of the Tritubercular Theory or not, this part of it appears to be beyond question.

3.— *Neck rather short, slender and flexible, permitting quick and easy turning of the head in all directions. Trunk slender, flexible, ribs rather short and few in number, lumbar region long and comparatively flexible.* These features characterize all early Tertiary mammals, without exception.

4.— *Tail very long and flexible, with strong muscles towards the base, and probably prehensible.* All primitive Tertiary mammals have remarkably long and strong tails. These differ from those of the cats and resemble those of the prehensile-tailed monkeys in the greater breadth of the zygapophyses of the proximal caudal vertebrae and great size and length of the median caudals.

5.— *Shoulder girdle of scapula and clavicle.* No indications of a separate coracoid have been observed in early Tertiary mammals, but the clavicle was certainly developed in the ancestors of several groups which do not now possess it, and was probably generally present in the earliest types.

6. — *Ilia narrow and rod-like,* gluteal muscles long and slender.

7. — *Upper members of limbs comparatively long and loosely jointed to the trunk, permitting great freedom of motion.* The

great relative length of the humerus and femur is a striking feature in the limbs of all early Tertiary mammals. In the evolution of the limbs for running the femur and humerus have generally been reduced in length and compacted into the flank, while the lower legs and feet are elongated. This places the heavy muscles high up on the limb, and by bringing its centre of gravity near to the proximal joint, enables it to swing more rapidly through a considerable arc. Thus the animal gains in length of stride without losing in quickness of step and can maintain a high speed for a long distance with less fatigue.

8. — *Ulna and radius separate, equal in size, radius with round head, permitting free supination and pronation. Tibia and fibula separate with probably more limited motion.*

9. — *Wrist and ankle very flexible, all the carpals separate and a centrale present. Astragalus with flat trochlea, distinct neck and rounded head.* This type of carpus and tarsus is found in all Basal Eocene mammals. It is retained with but little change in primates, insectivores, most rodents, and some other groups. Its gradual conversion into the various types seen in other groups is demonstrable in the Amblypoda, Condylarthra, Carnivora, partly so in the Proboscidea and Edentata, but not in the Artiodactyla and Perissodactyla which have already developed their peculiar types of astragali when they first appear in the geological record.

10. — *Five digits on each foot, the joints permitting of very free motion of fingers and toes, which were tipped by small claws.* The argument for the derivation of all mammals from pentadactyl ancestors has been fully set forth by Cope and others. The derivation of the hoofed from clawed types is likewise indicated in various lines of descent as now known.

11. — *First digit more or less opposable in both manus and pes.* This is contrary to the usual assumption that the opposable thumb found in several groups of arboreal mammals is in each case a new adaptation to their habits of life. But there is considerable evidence for it. In the first place, as far as we can trace back the history of each of the arboreal groups, we find their first ancestors with the first digit as fully opposable as in the modern representatives (*e. g.*, the Middle Eocene primate

Notharctus). Second, in those groups which have not an opposable thumb, we find as we trace back their ancestry that the trapezium, whose form and facets give the surest indication on this point, approaches more and more nearly to the type preserved in the Primates, etc. It becomes large, triangular, with very concave distal facet for the digit, and round-conical proximal faceted end abutting against the scaphoid, trapezoid and centrale. In the four Basal Eocene mammals (Pantolambda, Euprotogonia, Clænodon and Dissacus) in which this part of the skeleton is known, the form of the bone is surprisingly uniform, and when the manus is put together, the first digit is thrown partly outward from the rest of the hand, and permits of much freer motion than the remaining digits, with a considerable degree of opposition. With the development of the foot for terrestrial locomotion the trapezium and first metacarpal lose their mobility, the rounded conical proximal facet of the former separates into two flat facets at right angles for scaphoid and trapezoid, its distal facet becomes more plane and its whole distal end reduced in width and closely appressed against the proximal end of the second metacarpal, which it overlaps. In the further evolution of the running foot the first digit is reduced to a nodule and finally disappears, and the trapezium usually follows suit, the trapezoid either remaining separate (Perissodactyla) or being consolidated with the magnum (Artiodactyla).

The primitive opposability of the hallux is less clearly indicated, but the close resemblance in the form and arrangement of the internal tarsals, especially the internal cuneiform, in all early mammalia, to the intermediate stage in the evolution of the running carpus outlined above, very strongly suggests that the original condition in the tarsus was the same as in the carpus, but that its evolution for terrestrial locomotion began earlier or proceeded more rapidly.

In the third place, if we suppose, as many anatomists have done, that the so-called first metacarpal is really a proximal phalanx, and that the trapezium is the true first metacarpal, the hypothesis that all mammals passed through a stage when the pollex and hallux were opposable would supply a good reason

for the development of this anomaly, and would explain (*a*) the presence of but two phalanges on digit I, three on each of the others; (*b*) the epiphysis of digit I being proximal as in the phalanges, instead of distal as in the remaining metapodials; (*c*) the anomalous musculature of digit I on all mammals, the object of which is clearly seen when the digit is opposable, but is quite unexplained otherwise.

It would be beyond the purpose of this article to give at all fully the facts which support the above characterization of the primitive mammalia, but enough has been said to show the general nature and force of the evidence on which it is based. The modern orders of mammals have departed to a varying degree from this primitive type. The arboreal primates retain most nearly the primitive character, except that the limbs are elongated, the face is shortened and the brain greatly increased in size and complexity. The rodents, largely perhaps on account of their small size, have usually retained a great deal of the primitive skeleton character, but the dentition is much modified — least of all in the arboreal squirrels, which are almost unaltered in dental characters from the first known rodentia of the early Tertiary (Paramys, etc.). The Insectivora likewise retain many primitive characters, but in most cases in combination with one or another high specialization of an unusual kind. The Carnivora retain the primitive character more or less completely in the neck, trunk and legs, but show much greater adaptive changes in the feet and especially in the teeth. (Several of the Creodonta have a more or less opposable pollex, but this is lost in the later carnivora.) The Ungulata are by far the most highly altered group among the land mammals, almost every part of the body having gone through great adaptive changes, although the evolution is most marked in teeth and feet. We are able to trace the history of these changes more fully in this than in any other order, as its geological record is more complete. The Edentata early developed certain remarkable specializations which soon obscured their primitive characters. Of the remaining orders of placental mammals our geological record is very imperfect, and their relationship to the central type mainly hypothetical. The

marsupials, as Dollo and Bensley have shown,[1] are probably descended from an arboreal type which must have closely resembled the arboreal ancestors of the placentals, but with distinctions in the number and succession of the teeth, the origin of which is not yet clear. In these, as in the placental mammals, the modern arboreal forms are the most primitive. But it should be remembered that we know comparatively little about the palæontology of the marsupials earlier than the Quaternary, while we are able in most of the families of Ungulata, Carnivora, Rodentia and some other orders of placentals, to trace back their ancestry into the Middle or Lower Tertiary, and find them in every case converging toward the type characterized above, and quite closely converging as we come into the Basal Tertiary. We are thus enabled to place the earliest divergence from this central type in the Middle or Upper Cretaceous.

It may almost be taken for granted that if the characters of this central type were in all respects as stated above, it must have been of arboreal habitat. All its adaptations would be suitable for such a mode of life, and some would be more or less unsuitable for any other. The various modern groups (monkeys, squirrels, arboreal insectivores, opossums) which have retained this habitat are the least altered in structure, while the amount of structural change in other groups, as shown by their known palæontology, is proportioned to the change in their mode of life, the Ungulata exhibiting the greatest changes.

The hypothesis may be stated as follows:

The Cretaceous ancestors of the Tertiary mammals were small arboreal animals of very uniform skeletal characters, but probably somewhat differentiated in dentition according as fruit, seeds and nuts, or insects, formed the staple of their diet. At the beginning of the Mesozoic the available modes of life for land vertebrates were chiefly the amphibious-aquatic,

[1] A further development of the arboreal adaptation of the foot appears to have distinguished the marsupials, in the complete opposability of the hallux, with enlargement of the fourth digit and syndactyl reduction of digits II and III. It is this feature that is regarded by these authors as especially indicating arboreal habits.

the arboreal and the aerial, the terrestrial habitat being subordinate because the upland Flora was largely undeveloped or inedible as compared with its present condition. The three available provinces were occupied by reptiles, mammals and birds respectively. In the later Cretaceous the spread of a great and varied upland flora vastly extended the terrestrial province, and opened a new and constantly widening field for the expansion of the mammalia. These then commenced a great evolution, the new terrestrial groups expanding continually and becoming adapted to various modes of life. The arboreal types maintained or increased their lead in intelligence, but changed comparatively little in other respects. The terrestrial types became far more numerous and dominant, adapting their primitively arboreal organization to their various modes of life, yet retaining, in spite of extensive changes, a certain fixity of type which had been impressed upon them by their long arboreal residence.

The great extension of the terrestrial province in the Tertiary may be supposed to have opened a correspondingly large field for the expansion of the birds, but these, retaining in the main their aerial life, suffered but little change in organization, and the vast majority are today as homogeneous in skeleton structure as the mammals were at the beginning of the Tertiary. Coincident with the expansion of the terrestrial province was a great contraction of the amphibious-aquatic province. The extensive swamps and deltas and great inland seas of the Cretaceous, shrank at its close to small proportions, and the Reptilia underwent a corresponding diminution, some groups completely disappearing, others surviving through the Tertiary in continually decreasing numbers, the land reptiles (lizards and snakes) alone prospering. Both birds and reptiles, so far as they have retained their typical habitats, have changed but little structurally since the Mesozoic; only the few terrestrial reptiles and terrestrial or aquatic birds show an amount of change comparable with that in the terrestrial mammalia. It would seem therefore that all the facts accord with the explanation of the evolution of mammals during the Cenozoic as caused by their invasion of a new province and change of habitat from arboreal to dominantly terrestrial.

The little that is known of the Mesozoic Mammalia fits in with our hypothesis of their arboreal habitat but adds little to the evidence in its favor. Practically nothing is known of their skeletal structure; they are all of small or minute size, with teeth of insectivorous or granivorous type. They have been referred to monotremes, marsupials and insectivores, in each case on very insufficient evidence, but their ordinal relationships have little to do with the question of their habitat and need not be considered here. Their minute size, and association, in strata of fresh or brackish water origin, with large amphibious and aquatic reptiles and with abundance of fossil wood, suggest that the deposits in which they occur were laid down in extensive forest-clad river deltas and coastal swamps, and that the minute mammalia represent the arboreal fauna of these forests.

I am not well acquainted with the embryologic evidence which might bear upon the hypothesis advocated in this paper. Most investigations into mammalian ontogeny have had other problems in view. The deviation of placentals from marsupials or vice versa, and the ultimate origin of the mammalia from amphibian or reptilian ancestors, do not directly affect the question of the habitat of the Mesozoic ancestors of the Tertiary mammals. But undoubtedly important evidence on this point could be obtained from the ontogeny of their modern descendants, although not, perhaps, of the same force as the more direct evidence from palæontology.

AMERICAN MUSEUM OF NATURAL HISTORY,
June 15th, 1904.

LOCALIZED STAGES IN COMMON ROADSIDE PLANTS.

JOSEPH A. CUSHMAN.

THE plants considered in the present study are of common occurrence along country roadsides. With, perhaps, the exception of some of the early stages of development, the leaf forms noted may be found on country roads in the spring or summer. Although among our commonest plants, some actually classed as weeds, the stages shown in their development are as striking as could be found in any plants. The stages in development of other common plants have been described (*Amer. Nat.*, Vol. 36, No. 361), as well as some exotic plants of the Botanic Gardens of Harvard University (*idem.*, Vol. 37, No. 436). My thanks are due to Dr. R. T. Jackson for corrections and helpful suggestions. Each species is treated separately and its stages described in detail.

Thalictrum polygamum Muhl. Figures 1, 2.

(Tall Meadow Rue.)

Although this plant does not become conspicuous by its flowering until midsummer, its early growth from the rootstock and seedlings must be looked for in moist ground very early in the spring.

In the seedling (Fig. 1) the first nepionic leaf is simple, with three lobes. Such a first leaf is frequently found, but fully as often the first leaf is like the second leaf in the figure. The second leaf is trifoliolate, each leaflet being like the whole of the first nepionic leaf as figured. From this point the leaves of the young plant, as added, increase in complexity, the plant finally producing the 2–3 ternately compound leaves characteristic of the adult.

As the plant is a perennial its early spring growth may be easily studied.

When first noted it usually has complicated leaves, but if the very earliest growth is looked for, leaves will be found exactly comparable to those of the seedling. The trifoliolate form is commonest, but in some cases, especially where the plants grow in sandy soil, the first leaf will be simple, as in the first leaf of the seedling. The steps in the further complication of the compound leaf follow the same stages as in the seedling, but usually more rapidly, arriving at the typical leaf of the species by fewer stages than in the seedling. This is a good example of acceleration of development seen in localized stages.

FIG. 1.—Seedling of *Thalictrum polygamum*, showing cotyledons, *c*, *c*, and first and second nepionic leaves, the first with 3, the second with 5 leaflets.

The plant produces great masses of the small flowers, and the strength thus used up is deducted from the amount which goes to leaf development, with the result that below the flower there is always shown localized senescence, exhibiting regressive development. Figure 2 shows leaves in the series below the flower panicles. There is a gradual reduction of the proximal portion as shown in leaves 1 and 2, until a leaf is produced (Leaf 3 of Fig. 2), in which the leaf is trifoliolate, as in leaf 2 of Figure 1, but having no lobes on the lateral leaflets. Next, the lobes of the terminal leaflet are reduced and the outline of all the individual leaflets thus becomes entire. Still later the two lateral leaflets disappear and a very small, simple, entire leaf is found (Leaves 5 and 6), simpler than anything seen in progressive development, either in the straight development of the seedling or the localized development in early spring

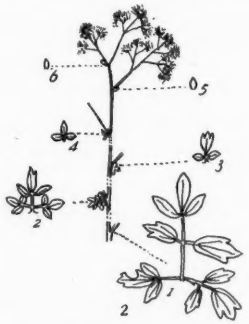


FIG. 2.—Flowering stalk of *Thalictrum polygamum*, showing localized reversionary senescence below the flower. Leaves 1–6 enlarged to natural size.

growth. The stages below the flower are very noticeable and are easily made out.

Daucus carota L. Figures 3–13.

(Wild Carrot.)

In this common weed very marked localized stages are found. The direct development of the seedling shows much acceleration as the first leaf of the ordinary seedling is considerably complex. The first nepionic leaf of the seedling of this species is shown in Figure 3. It is a decidedly compound leaf. The second leaf is still more complex.

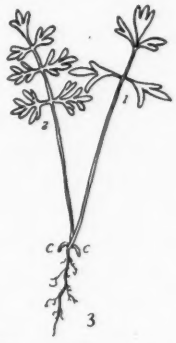


FIG. 3.—Seedling of *Daucus carota*, showing cotyledons, *c*, *c*, and first and second nepionic leaves.

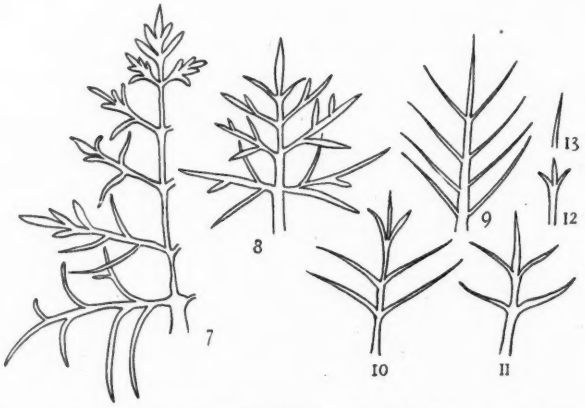
The spring growth is to some degree difficult of investigation, as the plant starts its growth very early. The first leaves seen under usual conditions of growth are very complex. It was therefore a matter of some trouble to obtain specimens showing reversionary characters. Finally plants growing under unfavorable conditions were sought. There the results were most gratifying. The plants shown in Figures 4–6 were found growing in sand along a railroad embankment where the conditions were decidedly adverse. They are of course weak specimens, although the size of the stem shows them to be adult plants of at least one year's growth.

FIGS. 4–6.—Spring growths of *Daucus carota*, 5–6 (1*a*–4*a*), weak growths; 4–6 (1–4), more vigorous growths.

In Figure 4, the first leaf of spring growth is simple and entire, the second leaf is similar but with a lobe on one side, the third leaf is trilobate and the fourth also. The fifth and sixth leaves have five lobes. In Figure 5, the stages except in the second leaf are exactly similar. From the plant

shown in Figure 6 two buds started. The series from the lateral weak bud, 1*a*–4*a*, are in the main like those of Figure 5, but the series from the stronger bud, 1–4, show a greater acceleration of development. The first leaf, No. 1, is comparable to the third leaf of Figures 4 and 5 and the third leaf of weaker growth on this same plant. The second leaf, No. 2, is comparable to the fifth leaf of Figure 4, and the third leaf is more complex than anything shown in the other cases of spring growth figured, but is closely comparable to the first nepionic leaf shown in the seedling (Fig. 3). In the localized development shown in early spring growth of weak plants, therefore, stages are found which are simpler than anything found in the direct development of the seedling. In vigorous plants spring growth is so much accelerated that these simpler stages are not found.

In Figures 7–13 are shown the leaves beneath the flower. Fig-



FIGS. 7–13. — Series of reduced leaves ("involucral bracts") found beneath the flower of *Daucus carota*, 7–8, upper leaves on the stalk; 10–13, clustered bracts beneath the flower, 13 being the upper one of the series.

ure 7 shows the typical adult leaf of the stem, Figure 8 the upper leaf on the stem in the specimen examined. By comparing Figure 8 with the second nepionic leaf of the seedling (Fig. 3), it will be seen that the two are very similar except that the leaf tips are more acute, almost spiniform. Below the flower cluster there are what are usually termed "cleft involucral bracts." These

are really reduced leaves as they are the morphological equivalent of such. Figure 10 is, in the number of its main division, comparable to the first nepionic leaf of the seedling (Fig. 3), and to leaf 3 of Figure 6 in the early spring growth. It differs however in not showing secondary lobes as seen in the other cases. Leaves of the next succeeding whorl have five main lobes, Figure 11, comparable to leaf 2 of Figure 6, or to leaf 5 of Figure 4. The one shown in Figure 12 is comparable to leaf 3 of Figure 4, or to the second stage in early spring growth. Figure 13 shows the ultimate reduction and a simple leaf comparable to the simplest first stage of spring growth. This series below the flower repeats in the reverse order, the steps shown in the progressive localized development of early spring growth and in the direct development of the seedling. In other words, it is regressive development repeating progressive development, but in the reverse order.

Baptisia tinctoria R. Br. Figures 14–16.

(Wild Indigo.)

This plant shows localized stages in a simple manner, yet very completely. In the direct development frequently starts off with the first nepionic leaf simple, broad and rotund, distally emarginate, the stipules not large but nevertheless noticeable (Fig. 14). The first leaf is broader and more rounded than the type leaf of the species (Leaf I of Fig. 16) in which the tip is slightly mucronate instead of slightly emarginate. The second nepionic leaf is trifoliolate, the leaflets rounded, wedge-obovate. The succeeding leaves are all trifoliolate, the stipules becoming smaller and less persistent.

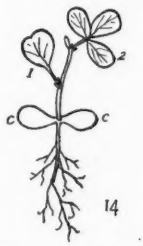


FIG. 14.— Seedling of *Baptisia tinctoria*, showing cotyledons, *c*, *c*, the first and second nepionic leaves, the first simple, the second trifoliolate.

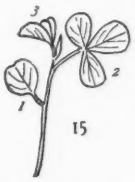


FIG. 15.–Early spring growth of *Baptisia tinctoria*, showing localized stages comparable to direct development seen in seedling.

Comparing these stages in direct development with localized stages in development seen in early spring growth,

the similarity is at once apparent. In some plants, probably but a year old, there were found many cases where the first leaf of spring growth was simple and emarginate, but like that of the first nepionic, much broader than the later leaves (Fig. 15). The stipules were also larger than in succeeding stages and in this again comparable to the first nepionic leaf of the seedling, showing a more accelerated condition. In all cases the second leaf of spring growth was trifoliolate. Those which were found with the spring growth starting off with a simple leaf were obtained in a situation unfavorable to the plant and thus favoring such retarded conditions of growth. The overlying loam had been removed from a glacial sand plain, leaving the sand exposed on a south slope. This gave a poor supply of moisture and exposed the plants to the full force of the sun. As a result, the plants showed a retarded development.

16

FIG 16.—Flowering stalk of *Baptisia tinctoria*, showing the reduction of characters in the localized senescence below the flower.

In the adult plants, when in flower, cases of localized senescence are not infrequent. Below the flowers, the last leaf is often simple, comparable to the first nepionic leaf of the seedling (Fig. 14), and to the first leaf of spring growth in feeble or retarded plants (Fig. 15). This reversionary condition below the flower is not usually shown, however.

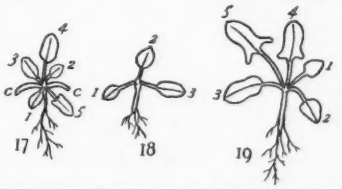
Rumex acetosella L. Figures 17–19.

(Sheep Sorrel.)

The peculiar auricled form of the leaves of this plant furnishes a means for study of stages, although the leaf is not compound as in the preceding cases. The seedling (Fig. 17) has the first and second nepionic leaves ovate, tapering somewhat at the base and with acute apices. In the third leaf the base is broader and the tip more blunt. The fourth leaf has a much broader base and more blunt apex so that it assumes a

roughly oblong shape. The fifth leaf has the auricled base characteristic of the species. Later leaves hold to this character. The early leaves of the seedling are red while later ones are green.

Turning to the early spring growth, very similar stages are noted (Fig. 18). In this weak plant the stages are exactly the same, leaf for leaf, as in the seedling after the cotyledons. In Figure 19, the early growth of a somewhat stronger plant, the first two leaves are similar to the first two of the seedling. The auricled form appears here in a vigorous plant in the fourth leaf, one stage earlier than in the seedling. The leaves in the early spring growth also resemble the seedling in their reddish color, but this is a superficial resemblance and not one of true repetition. It is dependent upon other causes.



FIGS. 17–19. — Seedling and early spring growths of *Rumex acetosella*. 17, seedling, showing cotyledons *c*, *c*, and first five nepionic leaves; 18–19, early spring growths showing stages by which the auricled form of base is reached.

On the flowering stalk there is a reduction of the base in the same manner, but in the reverse order, until below the flower there are linear leaves with narrow apices and bases. Thus the first leaves of the direct development in the seedling, the first leaves in the localized development in early spring growth and the last leaves in the reversionary localized senescence below the flower are without the auricled bases. In all other parts of the plant the leaves have the auricled base typical of the species.

Potentilla canadensis L. Figures 20–23.

(Common Cinquefoil.)

In this plant the seedling usually has the first nepionic leaf simple, the second ternate (Fig. 20). Succeeding leaves are ternate but apparently five palmate, due to the splitting of the lateral leaflets into two parts as shown in leaf 4 of Figure 21, a spring growth.

The early growth of this plant from adult roots is usually strong, but some plants have simpler leaves than characterize the adult. Over a hundred young plants were examined, all in an early condition of spring growth. Of these, the great majority had already the dissected ternate leaf, typical of the plant. Between fifteen and twenty of the smaller plants had the early leaves ternate, without dissection of the lateral leaflets (Fig. 22, leaf 2). In this specimen the first two of the early leaves had this character. In only one case in the hundred or more examined was a simple leaf found as the first of the early spring growth. In this specimen (Fig. 21) the first leaf was simple, the second ternate, and the succeeding ones of the typical dissected ternate form. This shows the rarity of this stage both in seedlings and spring growth, it being usually skipped by acceleration.

20

FIG. 20.—Seedling of *Potentilla canadensis*, showing cotyledons, *c*, *c*, and first and second nepionic leaves, the first simple, the second trifoliolate.

In the flowering there is usually little reduction, for the flower is comparatively very small and not confined to the end of the shoot. The leaf from the axil of which the flower comes, may be reduced to simple ternate one, but in the specimens examined no further reduction was found. In the late season's growth, however, very definite senescence is seen (Fig. 23). Plants were obtained in late November, when the leaves were nearly or quite dead, where the last leaves were reduced very frequently, to a simple ternate form, as shown in leaf 5, Figure 23. In one case out of those of this late growth which were examined, there was a simple leaf as the last leaf of the season's growth (No. 6, Fig. 23). This leaf, the last of the senescent ones of the season's growth, is comparable to the simple leaf seen in the first stage in the direct development of the seedling, and also to the first leaf of the

21

22

FIGS. 21–22.—Early spring growths of *Potentilla canadensis*. 21, showing exceptional case where first leaf is simple.

23

FIG. 23.—Final season's growth of *Potentilla canadensis*. A rare case in which the last leaf, no. 6, is simple, due to lack of growth force at the end of the growing season.

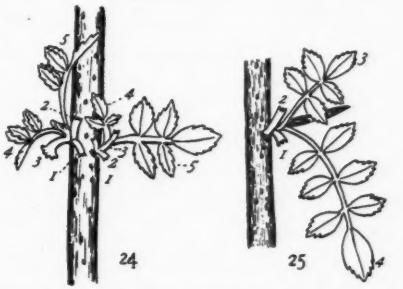
localized development, seen in the early spring growth. This is due to the lack of strength in the latest part of the season's growth and a consequent reduction follows. In this senescence then, the same stages are found, but they are developed in the reverse order.

Sambucus canadensis L. Figures 24–25.

(Common Elder.)

This seedling of this plant was not obtained, but one of another species, *S. nigra*, is figured by Lubbock (*Seedlings*, vol. II, p. 51, Fig. 420). In this species the leaves are in pairs. The two first pairs of nepionic leaves are simple, toothed, and the third pair is trifoliolate.

In the early spring growth of our species there are first, leaf-like bracts shown in Figures 24 and 25. These are notched or toothed at the distal end. In most cases there are three of these teeth or in some cases five. These teeth seem to represent the reduced leaflets of a compound leaf — in the commonest case a trifoliolate one. In such a case the first true leaf is trifoliolate or it may have five leaflets. In some cases, after the three-toothed bract there is a five-toothed one, usually more expanded and leaflike. Such a form is not followed by a trifoliolate leaf, but, in all the cases noted, by a leaf with five leaflets. These teeth then appear to represent the reduced leaflets, for if they did not there would be no reason against producing a trifoliolate leaf directly after the five-toothed bract. These bracts might be thought of as the stage representing a simple toothed leaf, but this definite succession of a leaf with five leaflets after a bract with five teeth seems to indicate them as reduced leaflets and not true teeth.



FIGS. 24–25. — Early spring growths of *Sambucus canadensis*. 24, showing the five toothed bract followed by a leaf with five leaflets.

Beneath the flower there may be a very slight reduction in the number of leaflets, but as a rule it is not carried to any noticeable extent.

Chenopodium album L. Figures 26–36.

(Lamb's-Quarters. Pigweed.)

This very common weed shows excellent localized stages. It is an annual and therefore shows it simply in the localized senescence below the flower. The seedling (Fig. 26), shows the direct development. The first two nepionic leaves are narrowly oval, tapering at the base and apex, with the basal portion not broader than the similar apical portion. The third leaf has a broader base and in the fourth it has become decidedly angled. In succeeding leaves the base becomes angulate-toothed (leaf 9). This leads quickly to the adult character (Fig. 27), and is continued until flowering. Then comes the reduction shown in the series (Figs. 27–36). This series represents leaves in the axils of which branches or flowers are produced. The

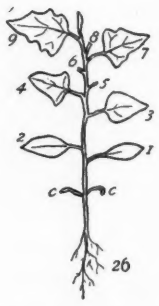
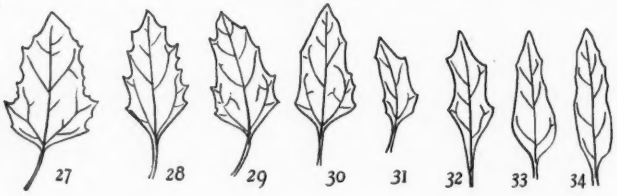


FIG. 26. — Seedling of *Chenopodium album*, showing cotyledons, *c*, *c*, and several of the nepionic leaves.



FIGS. 27–36. — Series of leaves on the stalk of *Chenopodium album*, showing the stages in the reduction from 27, the typical species leaf, to 36 the linear, reduced leaf below the flower.

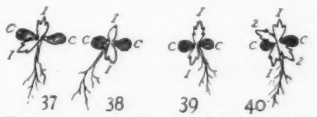
typical many toothed condition shown in Figure 27, is, in succeeding leaves, reduced until finally the simple leaves shown in Figures 35 and 36 are produced below the flower. The

stages passed through are very similar to those in the direct development of the seedling, but are in the reversed order of sequence.

Achillea millefolium L. Figures 37–42.

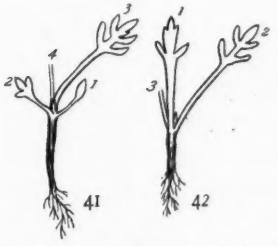
(Common Yarrow.)

The seedlings of this plant are very similar to those of *Tanacetum vulgare* L., as may be seen by a comparison of the figures of the seedlings of that plant (*Amer. Nat.*, vol. XXXVI, p. 881, Nov. 1902) with those of Achillea given here (Figs. 37–40). Both plants belong to the same tribe of the Compositæ.



FIGS. 37–40. — Seedlings of *Achillea millefolium*, showing differential acceleration in different individuals. 37 and 40 showing normal individuals, 38 a retarded, 39 one that is especially progressive.

There is much variation in the seedlings as was also noted in Tanacetum (*loc. cit.* p. 871). The first pair of nepionic leaves are usually three toothed; the second pair five toothed (Fig. 40). As shown by the figures this may be decidedly varied. Figure 37 shows the typical first pair of leaves; Figure 40 in addition the typical second pair. Figure 38 shows a retarded individual where the character of a three-toothed leaf, usually taken on in the first pair of nepionic leaves has not appeared, except as indicated by a single tooth of one leaf. Figure 39 shows an accelerated individual where the character of a five-toothed leaf, characteristic of the second pair of leaves, is shoved back and appears in one leaf of the first pair.



FIGS. 41–42 — Early spring growths of *Achillea millefolium*, showing differential acceleration in the localized development of two individuals, though both are more retarded than those usually found.

In the early spring growth better results were obtained than in the case of Tanacetum. Specimens of Achillea were found growing in the sandy railroad embankment which has been previously referred to. As in Tanacetum, the simplest leaves as a rule seem to be five toothed as in Figure

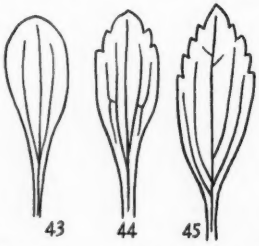
42. In rare cases, however, plants were found which had the first leaf with three teeth. In the specimen (Fig. 41), the first leaf was simple like one of the first nepionic leaves shown in Figure 38; the second was three toothed like the first nepionic leaves of the typical seedling (Figs. 37 and 40), and the third leaf has five teeth as was so commonly found as the first stage from rootstocks in the early spring growth. This then is a very retarded individual and repeats in its localized development, all the main stages seen in the whole series of seedlings representing the direct development.

Beneath the flower reduced leaves are also found. At the junctions of the stems of the compound corymb, leaves are found which are like those of the early spring growth and seedling in that they are simple and but few toothed. At the upper portion near the ultimate branchings are found leaves with five and three teeth and in some cases, simple entire leaves. These leaves are seen to repeat the same stages as in the localized development shown in spring growth and in the direct development of the seedling but in the reverse order. It is still another case of the localized reversionary senescence already referred to.

Aster acuminatus Michx. Figures 43–48.

(White Wood-aster.)

The seedling of this species was not obtained but a comparison of the early spring growth of an adult plant with the portion below the flower heads shows striking similarities. The stages are very simple, varying mainly in the number of the lateral teeth.

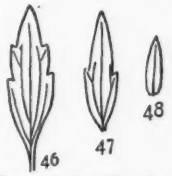


FIGS. 43–45.—Leaves of *Aster acuminatus*, showing three of the stages from the entire radical leaf 43, to the typical species leaf, 45.

In the early spring growth of a plant a year or more old, the radical leaves are at first entire and somewhat spathulate (Fig. 43). The next leaves have two lateral teeth and succeeding leaves have two lateral pairs (Fig. 44). In further development three lateral pairs are

produced and in the mature condition the leaves have four pairs, as in Fig. 45, which represents the typical leaf of the species.

Leaves like that shown in Fig. 45 are produced until the time of flowering. Then a reduction in the number of teeth takes place. Leaves with four, then three, pairs of lateral teeth are produced and nearer the flower heads, leaves with two pairs are shown in Fig. 46, later with the single pair (Fig. 47), and finally below the flower, the simple leaf shown in Figure 48. The reduction here is carried on in a definite manner and retraces exactly, in reversed order, the same stages that are passed through in the early spring growth, so that, using numbers for the lateral teeth, we may represent the stages graphically, calling the entire leaf number 1, as follows:



FIGS. 46–48. — The three final stages in the localized senescence below the flower of *Aster acuminatus*, 48 showing the last stage in the reduction.

Early spring growth . . . . . to . . . . . Flowering

1, 3, 5, 7, 9 . . . . . 9, 7, 5, 3, 1.

Eupatorium perfoliatum L.

(Thoroughwort. Boneset.)

This well known plant shows in its leaf characters certain things which may be noted here as in the same line with the preceding cases. The main leaf character of this plant is the connate-perfoliate form of the leaf. This, however, by an examination of a flowering specimen, will be seen to occur on only a part of the stem. In the early spring growth of the plant, the bases of the opposite leaves are free and narrow. Later the coalescent form is taken on and kept until well toward the flowering. Then the early form is again taken on, the base of the leaves being narrowed and failing to meet.

A variety of this species, var. *cuneatum* Engel., is apparently a more primitive form. It keeps the early character throughout its life history, the leaves failing to coalesce at their bases. This variety also has fewer flowered heads than the typical form of the species.

The commonest plants illustrate well the principle of localized stages in development seen in the direct progressive development of the seedling, in localized stages of spring growth and in the localized senescence at flowering. It may be shown in a variety of ways, as noted in the present paper. In Thalictrum, Baptisia, etc., it was shown especially by change in the number of leaflets; in Rumex, by the changes in the auricled base; in Daucus, etc., by the change in the number of the teeth, and finally in Eupatorium, by the presence or absence of the connate form of the leaf.

Different individuals show variations due to differences in acceleration of development. There is a differential acceleration in individual seedlings, shown where the first nepionic leaf in various individuals is more progressive or more retarded than in the typical cases. In spring growth it is also shown in much the same way, and with a still wider range of variation. These differences in acceleration may be caused by poor conditions, such as poor soil, lack of sufficient moisture, cold, etc., and by internal causes not accounted for in the above.

Regressive development, seen in the localized senescence below the flower, is shown in many cases to be more reversionary than stages in the usual seedling. When a large number of seedlings are examined, however, such extreme cases of variation may be seen which would otherwise be overlooked.

BOSTON SOCIETY OF NATURAL HISTORY,
May, 1904.

AN ARRANGEMENT OF THE FAMILIES AND THE HIGHER GROUPS OF BIRDS.

R. W. SHUFELDT.

BIRDS constitute a class of the phylum Vertebrata, and belong to the branch Craniata. Above the latter subphylum they are associated with the Reptilia in the tribe Sauropsida, which last in time has divided into two now distinct classes, namely, Reptilia and Aves (see *A Classification of Birds, postea*). Of all the existing vertebrate groups, birds are, morphologically speaking, the most homogeneous; probably none of the phyla recognized by zoölogists are more so. There is a very considerable gap between a thrush and an ostrich, but it in no way compares, in the matter of profundity, with the gap that stands between man and the duckbill, or between an elephant tortoise and a garter snake. This morphological homogeneity in birds by no means renders their taxonomy any the less difficult for us; indeed, for very obvious reasons it greatly tends to enhance the intricacies of the problem. This fact is now so generally appreciated by avian classifiers that it is quite needless to discuss it in the present connection.

To classify birds correctly and to point out the natural relationships and interrelationships of all the species and subspecies now in existence we resort to various lines of research and employ data of widely different nature. In the field of palæontology we meet with a mass of material, the comparative study of which has led to the conviction that Aves and Reptilia have arisen from a common stock. The indications of this have by no means died out in certain existing representatives of these two classes of the Sauropsida. For example, it is quite apparent when we come to trace the ancestry of the existing ostrich and its surviving allies in various quarters of the globe. The trend backward in time is distinctly reptile-wards and eventually brings one to the consideration of a long-extinct assemblage of

forms from which not only have the ostriches arisen, but both modern birds and reptiles have been derived.

In the classification of existing birds, again, we have recourse to their anatomical structure or morphology, and incidentally their physiology to assist us, the first of these being a very powerful aid. By morphology is meant the science of the outer form and internal structure, and to be of practical value in taxonomy it must be made thoroughly comparative. As far as possible we also study the morphogenesis of birds or the genesis of form in their case through evolution. Of great assistance is the knowledge we derive from our researches into the comparative ptilosis and pterylography of the group and all that pertains to these related sciences. In our efforts, too, to seek out the true relationships of birds in order to arrive at a natural classification we must take into consideration, in the broadest possible sense, their embryology; their oölogy and nidiology; their habits and comparative longevity, and even their various notes and songs must be given due weight. Their geographical distribution, a very important factor to be studied in their taxonomy, is to be considered not only from the viewpoint of the present distribution of the species of the class over the earth's surface, but likewise a comprehension, as far as possible, of the question as to how that distribution came about. The data for the latter, in the case of birds, are extremely meagre, as it takes into consideration the migration and original habitats of various forms of the class during geologic times, and as but very few fossil remains of birds have been discovered in any part of the world, there has been in consequence but very little light thrown upon this latter side of the question. So far as it goes, however, it has its value, as has also, to some extent, a consideration of the migrations, *per se*, of existing species and subspecies.

In some of these sciences, as in the case of ptilosis and pterylography for example, not only must both sexes be studied and compared, but the young at all stages of their existence. Both ptilosis and pterylography furnish very useful data to assist us in the classification of Aves, and as exponents of a bird's topographical anatomy, for this purpose they are quite co-equal in the matter of importance with the osteological system of the internal

structure; indeed, ptilosis, pterylography, and osteology stand among the most important factors at our command, in the

FIG. 1.—Skeleton of the Great Bustard. *Otis tarda* Linn. The enlargement on the upper mandible is abnormal. Coll. Natl. Mus. No. 12,315.

economy of this group of vertebrates, that become available in their classification. Right here it will be as well to state, how-

ever, that we will never arrive at the true and natural classification of birds, through the employment for that purpose of any *single set* of morphological characters.

A study of the skeleton in birds, for example, carries us a long way toward an understanding of their various alliances and relationships; this is particularly the case on account of what is to be derived from avian palæontology, — the bones being, with few exceptions, the parts preserved. It is extremely unsafe and dangerous to the science of this subject, however, to thus employ the osseous system alone. The taxonomical scheme based upon such knowledge should be modified and corrected by the employment of every other fact, every particle of information that has been made known in the matter. To this end various characters that have been found to exist in the muscular, the arterial, the digestive, the nervous and other systems have proved to be of considerable use.

A comparative study of the beaks and feet; the various characters presented on the part of the plumage, especially as to color, structure, and style, often constitute admirable checks on a classificatory scheme of the class based on osteological data. Food and other habits when properly studied, and the results applied, are also efficient aids to establishing many of the primary divisions in our scheme; and a consideration of such data without reference to facts of any other kind, is sufficient to enable us to refer a duck, a hawk, or a thrush to their proper places in a taxonomical arrangement. In other particulars nidiological and oölogical studies are of value taken in connection with the anatomical and other ones enumerated. Some birds build no nest at all, others construct them of all manner of shapes and sizes and out of all manner of materials. Some birds lay but a single egg, while others may lay a dozen or more; some eggs are plain white and unspotted, others are of other colors and unspotted, still others are variously marked or possess other peculiar characters, — all such facts, however, when properly comprehended and assorted, may be employed in classification with distinct advantage. For example, certain birds possessing an association of osteological characters in their skeletons lay but two white eggs in an elaborately constructed arboreal nest,

while no other existing birds of the class Aves have a similar association of characters and habits. Here then nidiological and oölogical facts support and emphasize osteological ones in establishing affinities. Again, were we told that we had before us the

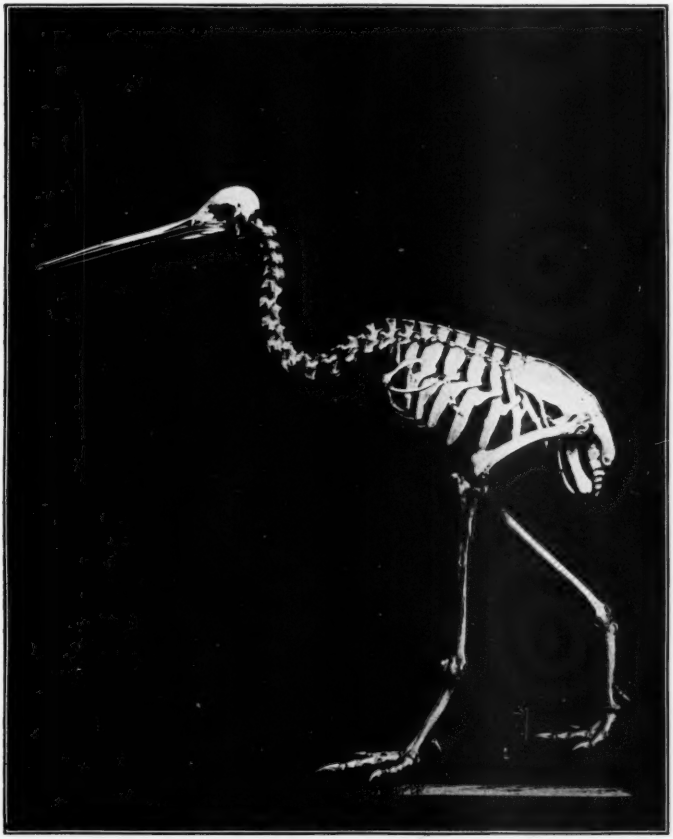


FIG. 2. — Skeleton of the Kiwi, *Apteryx australis* Shaw. Coll. Natl. Mus. No. 11,416.

skeletons of two *small* birds *in each* of which the osseous mandibles were slender and short; the nasals holorhinal; the basipterygoid processes absent; while in the sternum the keel was

well developed, and the posterior margin of the body of the bone presented *no notches whatever*, we would be quite at a loss to say what the two species were, but the moment that we added to these osteological characters the fact that it was also known that in the case of one bird it laid its *single* white egg in a burrow in the ground, while the other laid *several* white eggs in a little basket-like nest built by itself and found within the cavity of some great hollow tree, we would not hesitate to say but what the skeleton of the first belonged to some one of the smaller petrels, and that of the second to a swift, and very possibly a Chætura. Your opinion is considerably strengthened when you are told that the bird laying the single white egg had webbed feet, and was strictly a marine species, while the other possessed no such character of the feet, and was a typically insectivorus aërial land bird. When still other characters from other anatomical systems and parts are added, the true relations of the two species can be fixed with absolute certainty. In the present instance they chance to be very remote, although this by no means seemed to be the case when only the few osteological characters were mentioned. Such researches place forms in their proper groups, but to decide upon, or to discover the true relationships of, the families and main groups to each other is an entirely different matter and infinitely more difficult.

It is very important indeed that we should thoroughly comprehend the origin and evolution of such an assemblage of vertebrate forms as birds, and it is highly important, too, that we classify existing birds in such a manner that our classification conveys to the mind not only an orderly arrangement of our knowledge upon this subject, but a scheme representing as near as possible the actual and natural relationship of the major and minor groups of birds as they now exist. To convey such a scheme to the mind various plans and methods have been proposed and adopted by a number of ornithological taxonomers at different periods of the history of the science. It is not necessary that all of these be described here,— a few of the more prominent examples will answer our purpose. In his memoir "On the Osteology of Gallinaceous Birds and Tinamous," read before the Zoölogical Society of London on the 25th of

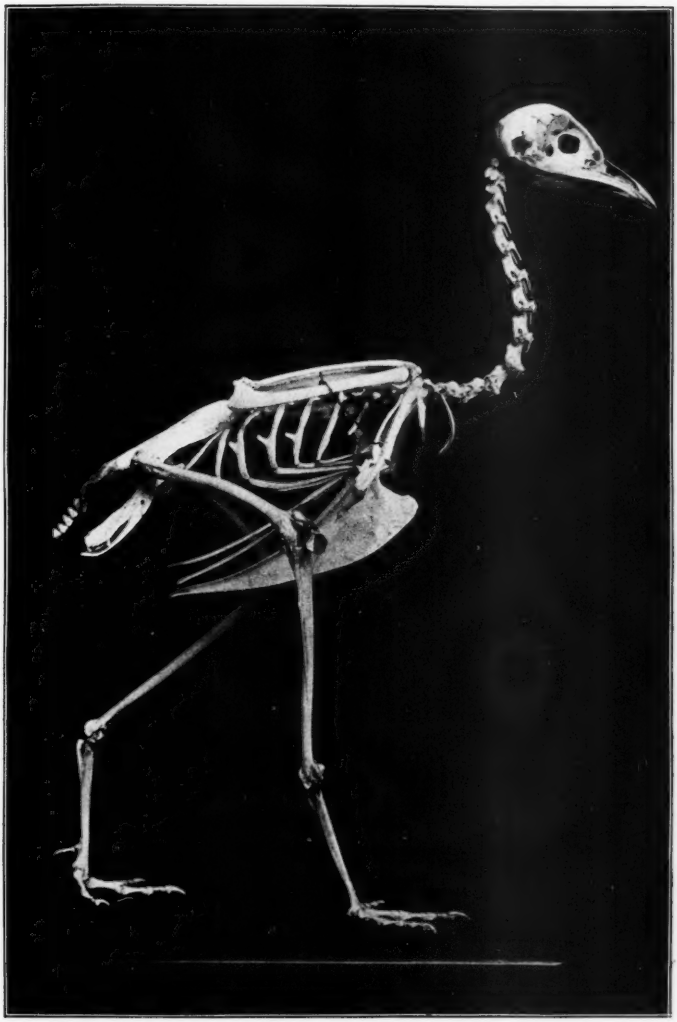


FIG. 3.—Skeleton of the spotted Tinamou, *Nothura maculosa* Temn. Coll. Natl. Mus. No. 17,949.

November, 1862, Professor Wm. Kitchen Parker gives us one of the earliest methods of setting forth in print the relationships of a number of birds treated of in the work named. These had to do with genera and not with families, and he conveyed his ideas on their relationships in two ways. One of these consisted in a method of what might be termed grouping, and the other the columnar method, or as it is sometimes called, the "linear," for the fact that the genera, or families, or the higher groups are printed in a linear sequence following in an order determined by what is supposed to be their relationships. Thus Parker said in the above quoted memoir on page 235, "I will first show, in two parallel columns, how both the Fowls and the Rails run insensibly through certain leading genera into the lowest (reptilian) types of diving-birds."

Notornis		Gallus	
Brachypteryx		Crax	
Ocydromus		Talegalla	
Tribonyx		Palemedea	
Crex		Anseranas	
Rallus		Plectropterus	
Gallinula		Anser	
Porphyris		Anas	
Fulica		Fuligula	
Podilymbus		Harelda	
Podiceps		Biziura	
Podica		Merganser	
Aptenodytes	Phalacrocorax	Colymbus	Alca

This method has its advantages, also its many disadvantages, and Parker felt the weight of some of these when he placed at the foot of the first column Aptenodytes aside from but near to Phalacrocorax, and in the second column Colymbus aside from Alca. So on the very next page or two (236, 237) he resorts to the grouping method and uses it in the case of Pluvialis, Talegalla, Hemipodius, Syrrhaptes, and Tinamus. This plan is well shown in the case of the last named genus,— thus :

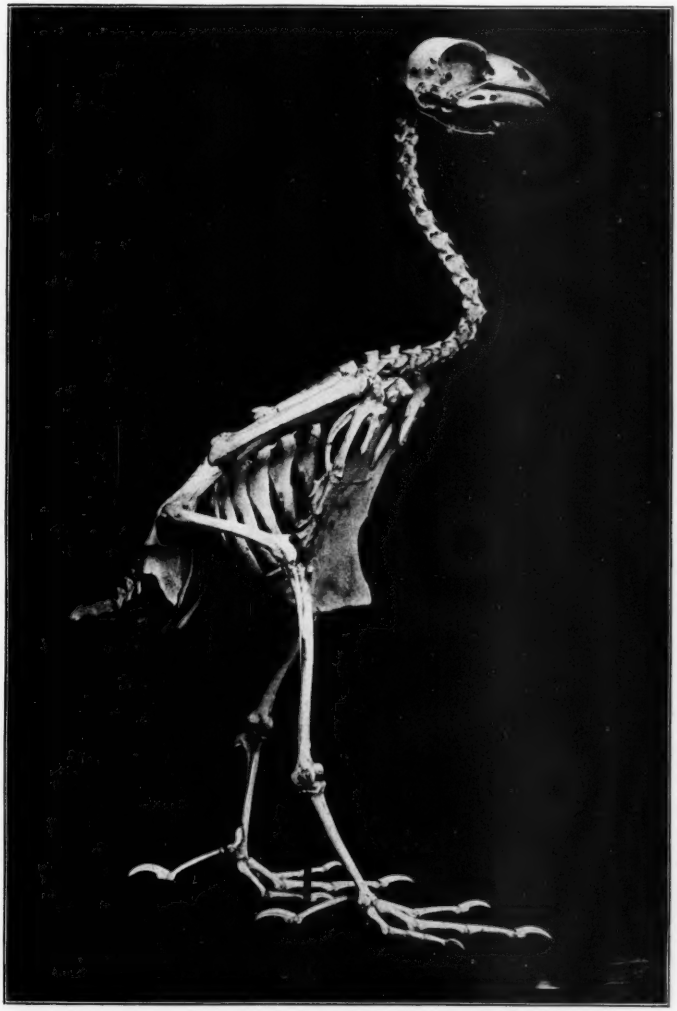


FIG. 4. — Skeleton of the Hoatzin, *Opisthocomus cristatus* Gmel. Coll. Natl. Mus. No. 18,518.

Gallus

Charadrius Dendrortyx Ocydromus

Syrrhaptes Hemipodius

TINAMUS

Apteryx Rhea

Casuarius

MAMMALIA REPTILIA

It is very evident that such a method of grouping could never be adopted, for to treat in general *all* the genera in any such a manner would certainly fill the subject with confusion, and the same would apply to the families being dealt with and printed according to any such an arrangement. It answers fairly well in the case of exhibiting the relationships of a single genus or other group, and for this purpose it has been adopted by some. A modification of this scheme consists in joining the names by *straight lines* in order to render the kinships more evident. This doubtless led to the use of the phylogenetic tree, a plan which will be more fully described farther on. In the matter of the linear method, with various modifications it has been employed by not a few avian taxonomers. Sharpe arranged Huxley's (1867) classification of Birds in this way in his now famous paper entitled, "A Review of Recent Attempts to Classify Birds" (1891, p. 4); Garrod resorted to it, and so did Sclater. Alfred Newton did to a limited extent, while Reichenow, Stejneger, and Fürbringer have presented complete schemes of avian classification in this manner,— Reichenow and Fürbringer employing the phylogenetic tree in connection with it. To some extent Seebohm also used the linear method, and Sharpe illustrating the latter employed a "diagrammatic map" giving the Seebohmian "Orders" in small circles, these circles bearing certain relations to each other, which relations were supposed to represent in a way, and convey to the mind, the relations the groups of birds themselves bore to each other. Finally these orders were surrounded by broken lines in such a manner as to show the kinships and connections of the subclasses found in Seebohm's scheme (*loc. cit.*, pp. 44–48). Sharpe also in his "Review" gives us an admirable example of the linear scheme

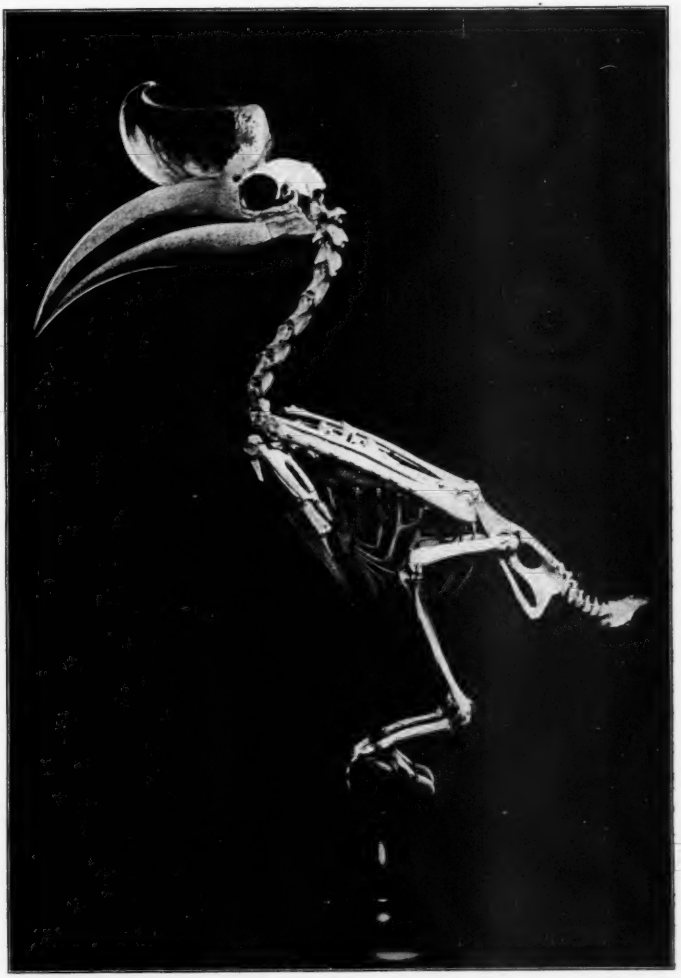


FIG. 5 — Skeleton of the Rhinoceros Hornbill, *Buceros rhinoceroides* Temm. Coll. Natl. Mus. No. 18,755.

of classification, and this is rendered vastly more useful from the fact that many of the *characters* of the suborders are conveniently footnoted in the same arrangement. He also employed the 'circle system' in several plates in his memoir, as well as a modification of the 'radiating line system,' and both with more or less effect (Plates IX–XII). This plan of presenting group characters is excellent in many particulars, and in connection with a modified linear scheme it has been employed by Cope in his Classification of Aves (*Amer. Nat.*, Vol. XXIII, No. 274, Oct., 1889, p. 869), and also by Hans Gadow (*P. Z. S.*, 1889). Still earlier than these it was used by Garrod (*P. Z. S.*, 1874).

Turning to the plan of the 'Phylogenetic Tree,' it has, among other authors, notably been employed by Reichenow (*Vögel. der Zoologichen Gärten*, 1882) and Max Fürbringer ("Untersuchungen zur Morphologie und Systematik der Vögel": '*Bijdragen tot de Dierkunde*,' Amsterdam, 1888. Tafln XXVI, XXVII). Reichenow's "Tree" is a very crude representation, and needs no special description in this place. It has, however, an historical interest for us, and a good copy of it may be found in Dr. Sharpe's 'Review' on page 23. A far more elaborate and widely known representation is Fürbringer's 'Phylogenetic Tree of Birds.' This brings up the main stem from the reptilian root-stock, from which, as it ascends, are thrown off the now dead limbs of a number of more or less known or even hypothetical groups of avireptilian or reptilioavian forms. Farther up, more extensive branches carry out the evolution of the main ostrich types, and soon above these the generous and complete development of the tree,— its many more or less closely dividing and branching limbs, boughs and stems, showing all the main modern or existing groups as they are supposed to have been given off from each other, or else to have arisen from the main trunk. This tree is horizontally divided by imaginary planes at certain points, dividing it into upper, lower and middle sections or horizons. Viewing the projections of these vertically we have the circular sections of the various branchings of the tree before us, and these will again give the relations to each other of the various groups. Three such projections are

obtained, which Fürbringer has represented for us upon three plates. The horizontally divided stems produced by these cutting planes are also grouped by a system of three kinds of

FIG. 6. — Skeleton of the Red-billed Toucan, *Rhamphastus carinatus* Swainson. Coll. Natl. Mus. No. 17,315.

surrounding lines which associate, in the opinion of this eminent authority, the minor and major groups in such a manner as to

have them furnish the requisite data upon which the linear scheme of this classification has been based. Without any manner of doubt this is the most elaborate provisional scheme of the classification of Birds extant, and beyond all question, in most particulars, the relationships of the groups as therein represented are correct, and, as far as possible, convey to our minds what has taken place in their evolution.

In setting forth a scheme of classification, the principal objection to the linear method is that it does not properly represent the branching or the derivation of new groups in time as the taxonomer has them in his mind. It brings some groups too close together, throws others too far apart, and in some instances in the lineal descent interpolates groups among others in such a way as to either do violence or misrepresent the true affinities and relationships of the forms as they exist or have existed in nature. By the employment of the phylogenetic tree we obviate a great many of these objectionable features so dangerous to the credit of a natural classification. Still notwithstanding all this, the *linear* method has been adopted in the present memoir, and for the reason that it is believed that the time is not yet at hand again, when the making of another elaborate phylogenetic tree for birds would be considered justifiable as we are still in the provisional stage. Therefore it has been adopted here. Further, it has been thought better to weave into this scheme such fossils of extinct types and species of birds as have come to hand, and this has likewise been done. For the rest, I have been influenced in the classification here set forth by my having read the literature of ornithology since boyhood; by my having studied everything that pertains to birds for a period extending over thirty years. This study has been constant, and has been undertaken in the field, in the closet and in the dissecting room. It has been devoted to every department of ornithology and of ornithotomy and morphology.

These studies have been supplemented by similar studies in the structure and habits of many mammals, reptiles, batrachians, fishes and other groups. These latter researches have convinced me that to render the matter of classification more homogeneous with respect to the vertebrate in general, or in fact to express

the conditions as they really occur in nature, the Class Aves is susceptible of being divided into but *two* orders, — the first or Order I, including the SAURURÆ, and the second, or Order II, including all other bird-forms, whether extinct or existing, that do not belong to Order I. This Order II is known as the ORNITHURÆ. There can be no possible doubt but what in the early history of birds these two orders arose from the same general ancestral stock, but during the geologic ages that have followed since, myriads of species have become extinct and the remains of this vast host have never, save in a few isolated instances, ever been found or seen by us. Hence the profundity of the gap now existing between the Saururæ and the Ornithuræ. As wide as this gap is, however, the discovery of a very few of the extinct and intermediate types would tend to greatly lessen its width. Nevertheless, we must classify the forms as we have them, and as we find them, and to do this consistently we must recognize the two orders aforesaid.

Fürbringer in his classification considers the Saururæ and the Ornithuræ each to represent a subclass. In this I cannot agree with him. Birds offer no such division, and are, as a matter of fact, too homogeneous in their structure to admit of it.

The Saururæ, as is well known, are at present represented by that unique, if it be unique, form Archæopteryx of the family Archæopterygidæ. There is every reason to believe that there once existed higher divisional groups of this family, therefore the order Saururæ is here subdivided into the supersuborder Archornithiformes and the suborder Archornithes (see "A Classification of Birds," *postea*). As thus created this order is capable of admitting into it any other fossil genus or genera of birds allied to Archæopteryx, whether they come from the Jurassic age of the Mesozoic epoch of Bavaria or from any other geologic horizon in any other part of the world. So far as is at present known they represent the oldest avian types in the hands of science.

The classification of birds set forth in the present memoir carries the arrangement down to include the families only, while for the higher groups, intermediate between the order and the family, I employ the superfamily, the suborder and the super-

suborder. To my mind such divisions can be very profitably employed to express the normal relationships of birds as they exist, and the relative nearness to each other of the various groups as compared with other natural assemblages of the Vertebrata.

Passing now to the consideration of the second order of birds (Order II, Ornithuræ) we meet at first with the array of the so-called ostrich forms it contains, or supersuborder II. These represent some of the lowest types of existing bird forms, and a number of extinct species allied to them have been discovered. It will not be necessary to discuss the systematic position of the Dromæognathæ (supersuborder II) for the reason that I have already recently done so in a paper published in *The American Naturalist* (Vol. XXXVII, No. 433, January, 1903, pp. 33–64. 2 figures), and this likewise applies to the supersuborder III, the Odontoholcæ. The Odontoholcæ are placed next in order after the ostrich-forms not for the reason that they possessed anything in their osseous systems that in any way connected them with the Dromæognathæ, but because they represent the archaic ancestral stock from which has been derived the existing Supersuborder Colymbo-Podicipitiformes (IV) containing the loons, divers, and grebes, and these last in the matter of organization stand among the lowest of known types of modern birds.

This group has been thoroughly treated in my published papers. A few of the more important groups, however, are still in press, as for example the "Osteology of the Accipitres" (Carnegie Museum); "Osteology of the Anseres" (Carnegie Museum); and the "Osteology of the Lariformes" (complete in manuscript). I now offer my scheme for *A Classification of Birds*. This classification requires in some of the groups illustrations in the way of bird skeletons that I have heretofore been unable to publish, and which will throw additional light upon the subject. These have been kindly photographed for me at the U. S. National Museum at Washington, and reproductions of those photographs are herewith presented, with the necessary descriptions.

A Classification of Birds.

Phylum : —
Vertebrata.
Branch : —
Craniata.
Tribe : —
Sauropsida.
Classes : —
Reptilia.
Aves.

Class Aves.

Order I. Saururæ.

Supersuborder	I.	Archornithiformes.
Suborder	I.	Archornithes.
Family	I.	Archæopterygidæ.

Order II. Ornithuræ.

Supersuborder	II.	Dromæognathæ.
Suborder	II.	Struthionithes.
Family	I.	Struthionidæ.
Suborder	III.	Rheornithes.
Family	I.	Rheidæ.
Suborder	IV.	Casuariornithes.
Family	I.	Dromaiidæ.
	II.	Casuariidæ.
	III.	Dromornithidæ.
Suborder	V.	Dinornithes.
Family	I.	Dinornithidæ.
Suborder	VI.	Æpyornithes.
Family	I.	Æpyornithidæ.
Supersuborder	III.	Odontoholcæ.
Suborder	VII.	Pygopoformes.
Superfamily	I.	Hesperornithoidea.
Family	I.	Enaliornithidæ.
	II.	Hesperornithidæ.

Supersuborder	IV.	COLYMBO-PODICIPITIFORMES.
Suborder	VIII.	PYGOPODES.
Superfamily	I.	Podicipoidea.
Family	I.	Podicipidæ.
Superfamily	II.	Urinatoroidea.
Family	I.	Urinatoridæ.
Supersuborder	V.	APTENODYTIFORMES.
Suborder	IX.	IMPENNES.
Family	I.	Spheniseidæ.
	II.	Cladornithidæ.
Supersuborder	VI.	PROCELLARIIFORMES.
Suborder	X.	TUBINARES.
Family	I.	Procellariidæ.
	II.	Puffinidæ.
	III.	Pelecanoididæ.
	IV.	Diomedeidæ.
Supersuborder	VII.	PELECANIFORMES.
Suborder	XI.	STEGANOPODES.
Superfamily	I.	Pelecanoidea.
Family	I.	Pelecanidæ.
	II.	Pelagornithidæ.
	III.	Phalacrocoracidæ.
	IV.	Odontopterygidæ.
	V.	Anhingidæ.
	VI.	Sulidæ.
Superfamily	II.	Phaëthonitoidea.
Family	I.	Phaëthontidæ.
Superfamily	III.	Fregatoidea.
Family	I.	Fregatidæ.
Supersuborder	VIII.	ICHTHYORNITHIFORMES.
Suborder	XII.	ICHTHYORNITHES.
Family	I.	Ichthyornithidæ.
	II.	Apatornithidæ.
Supersuborder	IX.	LARIFORMES.
Suborder	XIII.	LONGIPENNES.
Family	I.	Rhynchopidæ.
	II.	Stercorariidæ.
	III.	Laridæ.

Suborder	XIV.	ALCÆ.
Family	I.	Alcidæ.
Suborder	XV.	CHIONIDES.
Family	I.	Chionididæ.
Supersuborder	X.	CHARADRIIFORMES.
Suborder	XVI.	LIMICOLÆ.
Family	I.	Charadriidæ.
	II.	Arenariidæ.
	III.	Hæmatopodidæ.
	IV.	Aphrizidæ.
	V.	Scolopacidæ.
	VI.	Phalaropodidæ.
	VII.	Recurvirostridæ.
Superfamily	I.	Jacanoidea.
Family	I.	Jacanidæ.
Suborder	XVII.	CURSORÆ.
Family	I.	Thinocoridæ.
	II.	Dromadidæ.
	III.	Glareolidæ.
	IV.	Cursoriidæ.
Superfamily	II.	Otidoidea.
Family	I.	Œdicnemidæ.
	II.	Otididæ.
Supersuborder	XI.	STEREORNITHIFORMES.
Suborder	XVIII.	STEREORNITHES.
Family	I.	Phororhacidæ.
Supersuborder	XII.	GRUIFORMES.
Suborder	XIX.	GRUES.
Superfamily	I.	Gruioidea.
Family	I.	Gruidea.
	II.	Psophiidæ.
Superfamily	II.	Cariamoidea.
Family	I.	Cariamidæ.
Superfamily	III.	Eurypgoidæ.
Family	I.	Eurypygidæ.
	II.	Rhinochetidæ.
	III.	Mesitidæ.
	IV.	Aptornithidæ.

Supersuborder	XIII.	RALLIFORMES.
Suborder	XX.	FULICARIÆ.
Superfamily	I.	Heliornithoidea.
Family	I.	Heliornithidæ.
Superfamily	II.	Ralloidea.
Family	I.	Rallidæ.
	II.	Aramidæ.
Supersuborder	XIV.	APTERYGIFORMES.
Suborder	XXI.	APTERYGES.
Family	I.	Apterygidæ.
Supersuborder	XV.	GALLIFORMES.
Suborder	XXII.	HEMIPODI.
Family	I.	Hemipodidæ.
Suborder	XXIII.	CRYPTURI.
Family	I.	Crypturidæ.
Suborder	XXIV.	GALLINÆ.
Family	I.	Megapodidæ.
	II.	Cracidæ.
	III.	Phasianidæ.
	IV.	Tetraonidæ.
	V.	Odontophoridæ.
	VI.	Numididæ.
	VII.	Meleagridæ.
Suborder	XXV.	OPISTHOCOMI.
Family	I.	Opisthocomidæ.
Supersuborder	XVI.	PTEROCLIDIFORMES.
Suborder	XXVI.	PTEROCLETES.
Family	I.	Pteroclididæ.
Supersuborder	XVII.	COLUMBIFORMES.
Suborder	XXVII.	COLUMBÆ.
Family	I.	Treronidæ.
	II.	Columbidæ.
	III.	Peristeridæ.
	IV.	Gouridæ.
	V.	Didunculidæ.
Suborder	XXVIII.	DIDI.
Family	I.	Didida.
Supersuborder	XVIII.	PALAMEDEIFORMES.

Suborder	XXIX.	PALAMEDEÆ.
Family	I.	Palamedeidæ.
Supersuborder	XIX.	ANSERIFORMES.
Suborder	XXX.	ANSERES.
Family	I.	Gastornithidæ.
	II.	Anatidæ.
Supersuborder	XX	PHŒNICOPTERIFORMES.
Suborder	XXXI.	PHŒNICOPTERI.
Family	I.	Palæolodidæ.
	II.	Phœnicopteridæ.
Supersuborder	XXI.	PELARGIFORMES.
Suborder	XXXII.	HERODIONES.
Family	I.	Ibididæ.
	II.	Plataleidæ.
	III.	Ciconiidæ.
	IV.	Scopidæ.
	V.	Ardeidæ.
	VI.	Balænicipitidæ.
Supersuborder	XXII.	ACCIPITRIFORMES.
Suborder	XXXIII.	ACCIPITRES.
Superfamily	I.	Falconoidea.
Family	I.	Serpentariidæ.
	II.	Falconidæ.
	III.	Milvidæ.
	IV.	Pandionidæ.
	V.	Vulturidæ.
Superfamily	II.	Cathartoidea.
Family	I.	Cathartidæ.
Supersuborder	XXIII.	PSITTACIFORMES.
Suborder	XXXIV.	PSITTACI.
Superfamily	I.	Psittacoidea.
Family	I.	Nestoridæ.
	II.	Loriidæ.
	III.	Cyclopsittacidæ.
	IV.	Cacatuidæ.
	V.	Psittacidæ.
Superfamily	II.	Stringopoidea.
Family	I.	Stringopidæ.

Supersuborder	XXIV.	STRIGIFORMES.
Suborder	XXXV.	STRIGES.
Family	I.	Bubonidæ.
	II.	Strigidæ.
Supersuborder	XXV.	CAPRIMULGIFORMES.
Suborder	XXXVI.	STEATORNITHES.
Family	I.	Steatornithidæ.
Suborder	XXXVII.	PODARGI.
Family	I.	Podargidæ.
Suborder	XXXVIII.	CAPRIMULGI.
Family	I.	Caprimulgidæ.
Supersuborder	XXVI.	CORACIIFORMES.
Suborder	XXXIX.	LEPTOSOMATI.
Family	I.	Leptosomatidæ.
Suborder	XL.	CORACIÆ.
Family	I.	Coraciidæ.
Supersuborder	XXVII.	HALCYONIFORMES.
Suborder	XLI.	HALCYONES.
Family	I.	Dacelonidæ.
	II.	Alcedinidæ.
Suborder	XLII.	BUCEROTES.
Family	I.	Bucerotidæ.
Suborder	XLIII.	UPUPÆ.
Family	I.	Upupidæ.
	II.	Irrsoridæ.
Suborder	XLIV.	MEROPES.
Family	I.	Meropidæ.
Suborder	XLV.	MOMOTI.
Family	I.	Momotidæ.
Suborder	XLVI.	TODI.
Family	I.	Todidæ.
Supersuborder	XXVIII.	TROCHILIFORMES.
Suborder	XLVII.	TROCHILI.
Family	I.	Trochilidæ.
Supersuborder	XXIX.	JACAMARIFORMES.
Suborder	XLVIII.	GALBULÆ.
Family	I.	Bucconidæ.
	II.	Galbulidæ.

Supersuborder	XXX.	TROGONIFORMES.
Suborder	XLIX.	TROGONES.
Family	I.	Trogonidæ.
Supersuborder	XXXI.	COCCYGIFORMES.
Suborder	L.	MUSOPHAGI.
Family	I.	Musophagidæ.
Suborder	LI.	COCCYGES.
Family	I.	Cuculidæ.
Supersuborder	XXXII.	COLIFORMES.
Suborder	LII.	PAMPRODACTYLÆ.
Family	I.	Coliidae.
Supersuborder	XXXIII.	PICARIFORMES.
Suborder	LIII.	CAPITONES.
Family	I.	Capitonidæ.
Suborder	LIV.	RHAMPHASTIDES.
Family	I.	Rhamphastidæ.
Suborder	LV.	INDICATORES.
Family	I.	Indicatoridæ.
Supersuborder	XXXIV.	PICIFORMES.
Suborder	LVI.	PICI.
Family	I.	Picidæ.
Supersuborder	XXXV.	CYPSELIFORMES.
Suborder	LVII.	CYPSELI.
Family	I.	Macropterygidæ.
	II.	Cypselidæ.
Supersuborder	XXXVI.	EURYLÆMIFORMES.
Suborder	LVIII.	EURYLÆMI.
Family	I.	Eurylæmidæ.
Supersuborder	XXXVII.	MENURIFORMES.
Suborder	LIX.	MENURI.
Family	I.	Menuridæ.
Supersuborder	XXXVIII.	ATRICHONITHIFORMES.
Suborder	LX.	ATRICHONITHES.
Family	I.	Atrichonithidæ.
Supersuborder	XXXIX.	PASSERIFORMES.
Suborder	LXI.	MESOMYODI.
Family	I.	Pteroptochidæ.
	II.	Conopophagidæ.

	III.	Formicariidæ.
	IV.	Dendrocolapidæ.
	V.	Tyrannidæ.
	VI.	Pipridæ.
	VII.	Cotingidæ.
	VIII.	Phytotomidæ.
	IX.	Pittidæ.
	X.	Philepittidæ.
	XI.	Xenicidæ.
Suborder	LXII.	ACROMYODI.
Family	I.	Hirundinidæ.
	II.	Muscicapidæ.
	III.	Campophagidæ.
	IV.	Pycnonotidæ.
	V.	Timelidæ.
	VI.	Mimidæ.
	VII.	Troglodytidæ.
	VIII.	Cinclidæ.
	IX.	Turdidæ.
	X.	Sylviidæ.
	XI.	Vireonidæ.
	XII.	Ampelidæ.
	XIII.	Prionopidæ.
	XIV.	Lanidæ.
	XV.	Sittidæ.
	XVI.	Paridæ.
	XVII.	Zosteropidæ.
	XVIII.	Dicæidæ.
	XIX.	Nectariniidæ.
	XX.	Meliphagidæ.
	XXI.	Certhiidæ.
	XXII.	Mniotiltidæ.
	XXIII.	Motacillidæ.
	XXIV.	Alaudidæ.
	XXV.	Fringillidæ.
	XXVI.	Drepanidæ.
	XXVII.	Cærebidæ.
	XXVIII.	Tanagridæ.

Family XXIX.	Ploceidæ.
XXX.	Icteridæ
XXXI.	Oriolidæ.
XXXII.	Dicruridæ.
XXXIII.	Eulabetidæ
XXXIV.	Sturnidæ.
XXXV.	Paradiseidæ.
XXXVI.	Corvidæ.

OBSERVATIONS ON HEARING AND SMELL IN SPIDERS.[1]

ANNIE H. PRITCHETT.

ONLY a small amount of previous work has been done upon the senses of hearing and smell in spiders.

According to Campbell ('80) spiders are well provided with the means of feeling the slightest movements of their webs or other near objects. On their legs are long, slender, silken hairs which differ from other hairs in that they are attached to a disc on the integument.

Dahl ('83) found these hairs to vibrate to the tones of a violin and designated them as auditory hairs. Later ('84) he distinguished certain of these as organs of smell and attempted a classification of spiders according to the distribution of the various hairs.

Bertkau ('85) compared the so-called taste organs on the ends of the palps with the flask-shaped bodies on the antennæ of ants and spoke of them as organs of smell.

J. W. and E. S. Peckham ('87) found that with three exceptions all the spiders experimented upon by them gave responses to strong smelling substances, but the Epeiridæ alone seemed capable of hearing the vibrations of a tuning fork. Orb-making spiders were the most sensitive to these vibrations, while those that make no web gave not the slightest heed to the sounds, and in the former the sense seemed to be distributed generally over the whole epidermis.

Wagner ('88) insisted that the so-called auditory hairs are only capable of perceiving tactile sensations.

Gaubert ('90) considered the lyriform organs as organs of hearing.

[1] Contributions from the Zoölogical Laboratory of the University of Texas, No. 59. A thesis submitted to the Faculty of the Department of Literature, Science and Arts of the University of Texas for the degree of Master of Science.

McCook ('90) concludes that the senses of smell and hearing are very rudimentary and are distributed over the entire body. They are located in the delicate hairs which constitute the covering and armature, so that the nervous system receives through these organs or appendages impressions that may be considered analogous to hearing and smell in the higher animals. Further, the sense of hearing can scarcely be distinguished from that of touch as it is known to us. He thinks that even in the orb-weavers there is no true sense of hearing, but that the web filaments transmit the vibrations and the sensation is tactile rather than auditory.

Pocock ('93) found spiders sensitive to heat, provided with acute sense of taste, with defective sight and no hearing whatever.

Dahl (:04) designates the auditory hairs as trichobothria and makes an elaborate classification of suborders according to their distribution.

The two species used by me for experiment are *Geolycosa texana* Montg. and *Pardosa mercurialis* Montg. and are found in great abundance in Austin, Texas, and its vicinity. The large *Geolycosa texana* lives in underground holes of $\frac{1}{2}$ to $1\frac{1}{2}$ inches in diameter and digs its home on creek banks or in the fields wherever the ground is comparatively clear except for a close sod of native grass. *Pardosa mercurialis* has been found mainly under small surface stones along the banks of streams or in the dry beds during droughts, but sometimes occurs in great abundance far from water.

The specimens used for the observations were kept in cages made by fastening glass plates together at their edges with gummed linen, as described by Montgomery (:03).

1. Experiments on Hearing.

The apparatus used for these experiments were tuning forks of 128, 256, 320, 384 and 512 vibrations and a specially prepared, isolated cage. The cage was made of three glass plates fastened with gummed linen and covered with black paper,

except on the bottom. A small hole was left in the paper of one side to admit light and one in the top for observations. The bottom was of mosquito netting which served to admit the sound waves from below. The cage, supported at the three corners by wooden posts 10 *cm.* high, rested on a wooden float, the float in a stone jar filled with water and attached to it by rubber bands. A layer of sawdust three inches thick isolated the jar and stool upon which it stood from vibrations from without. The apparatus, though placed in a quiet, darkened corner of the laboratory, was used only when there were as few outside disturbances as possible.

a. Geolycosa texana Montg.

♀ No. 13 was placed in the hearing cage and left unmolested one hour. At the end of that time successive trials were made with tuning forks of 128, 256, 320 and 512 vibrations, but no response whatever was obtained. At two later dates the experiments were repeated but with no more definite results. The same results were obtained with three other females, in each case using all the tuning forks. Also a male, after remaining quiet one hour in the hearing cage was tested with all the forks but gave no response.

b. Pardosa mercurialis Montg.

♀ No. 5 was placed in the hearing cage and after an hour's intermission was tested with the forks but remained perfectly quiet. She was left in the cage over night and tested next morning but gave no response.

♀ No. 6 was tested by three separate series of experiments, the first after two intervals of an hour and the third after a half hour had elapsed, but she did not respond to any of the sounds. During the first series she cleaned her palps and legs in the normal way as if nothing unusual were happening. No responses were obtained on similar experiments with two other females and a male.

At another time a steel bar which gave a pitch of approxi-

mately 2300 vibrations was suspended above the hearing cage and struck repeatedly with a metal hammer. Eight fresh specimens were placed successively in the cage but no spider made any motion that could be interpreted as a response to the sound.

Again, a mason's trowel was held near the cage and struck several times with a metal bar producing a loud, crashing noise, but the spiders made no motion whatever.

2. EXPERIMENTS ON SMELL.

These experiments were undertaken to ascertain first whether the spiders possessed the sense of smell and second to localize the same, if possible, in case it was found to exist. The experiments were made mostly upon *Pardosa mercurialis*.

Two classes of the essential oils were used as tests. Those of the first class were the non-irritants, lavender, cedar, wintergreen, almond, juniper-berries, bergamot, cassia and cloves; of the second class, those irritants that will cause sneezing in man were oils of mustard and black pepper. The results from the use of the two irritating oils were essentially the same as those for the stronger oils of the non-irritating class, and the reactions were the same in every case only that they were more intensified with the oils of stronger odors.

The hearing cage was used for the smell experiments.

Small glass rods were dipped into the oil and the drop that adhered was held immediately below the cage. In each case the spider seemed repelled to a greater or less degree corresponding to the strength of the oil, and in no instance was it attracted toward the stimulus. The males and females gave exactly the same response, thus showing that neither sex has a superior sense of smell.

The responses were (1) turning away and moving as far as possible from the odor, (2) vibratory movements of the palps and mandibles, (3) raising each leg as the oil is applied beneath it. In some cases all the responses were given to a single stimulus, in others only one, or a combination of either two.

Experiments were made first on unmutilated specimens to

ascertain the normal reaction to odors, then upon individuals variously mutilated in order to localize the olfactory sense.

a. Observations on Unmutilated Individuals.

Lavender.— Tests were made with eight females and seven males and each responded by running from the stimulus. In four cases this was accompanied by motions of the palps and mandibles.

Wintergreen. — Seven females and four males. In five cases the palps gave definite vibratory responses and in the others the spiders turned away.

Bergamot. — Six males and six females. Each time the spiders turned away, and in seven instances responded with motions of the palps.

Cassia. — Six males and six females. All but one turned quickly away, and eight gave vibratory motions of the palps.

Clove. — Six females and five males. One female gave no response, six gave movements of palps and mandibles, while ten responded also by turning away.

Cedar. — Eight females and six males. The responses were quite indefinite, palpal vibration in two cases, and in four there was no motion whatever.

Almond. — Seven females. No palpal movements were given and the spiders turned away indifferently.

Juniper-berries. — Eight females and six males. The responses were quite slow and consisted generally in turning away. The palps were moved slightly but not in a vibratory manner.

Mustard. — Six males and eight females. The responses were no more decided than those given to strong oils of the non-irritating class. In only one instance were there definite palpal movements, and the spiders usually turned quickly away at first, then later more slowly, as if overcome by the odor.

Black pepper. — Six males and six females. The responses were quite slow and given after prolonged stimulation. Vibratory motions of the palps were entirely lacking.

b. Observations on Individuals with Palps extracted.

It next seemed desirable to determine the location of the olfactory sense, and for this purpose the oils that produce definite results with the unmutilated individuals were used exclusively.

Both palps were extracted with forceps at the femoro-trochanteral joint from twelve females and six males, and after a week had elapsed experiments were made with three non-irritating oils, lavender, wintergreen and bergamot.

Lavender.— In every case the spider gave definite responses to the stimulus. When the drop of oil was held directly beneath each leg successively, each responded by a slight, quick, upward jerk. Almost without exception the first pair were raised highest and held poised in the air several moments or until the other legs were stimulated. The second pair were not raised so high as the first, nor the third pair so high as the second, and rarely ever both at the same time. The fourth pair were usually raised only a little distance and then drawn up closer to the body while the spider moved away.

Wintergreen. — The same specimens, twelve females and six males, were used and practically the same results were obtained.

Bergamot.— A similar series of experiments was performed on the twelve females and responses corresponding to the above were given, though bergamot appears to offer a weaker stimulus than the other two oils used.

Cassia.— The palps were extracted from twelve other males and six other females and experiments were performed after twenty-four hours. In only one instance did the spider fail to respond, all others showing the usual reactions — the first pair of legs responding most definitely and the others less so. The spiders usually turned away after a few applications of the stimulus.

c. Observations with the First Pair of Legs Removed.

In five females and six males the palps were left intact but the first pair of legs were similarly removed with forceps. The

responses were exactly the same as in the foregoing series Thus it was shown that the sense of smell is not localized in the palps nor in any one pair of legs, but that each is capable of perceiving the stimulus to a certain degree and of giving a definite response to it.

d. Observations on Individuals with the Sense Hairs removed.

The theory has several times been advanced that the long, spiny hairs on the legs of these spiders are organs of special senses, accordingly all these hairs were cut off the tarsi and tibia of male No. 94 and after twenty-one hours it was tested with lavender oil. Each leg responded as do those from which no spines were removed.

Female No. 95 had the hairs cut from the entire leg and each leg sand-papered, still it gave the normal response to bergamot twenty-one hours after the operation.

Female No. 96 had all the legs sandpapered, yet after only an hour's time it responded normally to bergamot, raising each leg in succession.

Male No. 97 had the tarsus of each leg removed and the spider seemed to suffer more than when an entire leg was cut off. However after twenty-two hours it responded normally to bergamot, raising each leg as it was stimulated. It was not considered safe to cut the legs at any higher joint, but the experiments seem to indicate that the entire leg possesses the ability to perceive sensations of odors.

3. Conclusions.

1. Neither Geolycosa nor Pardosa respond to tuning forks of 128, 256, 320, 384 and 512 vibrations. No responses were given to a metal bar of approximately 2300 vibrations nor to the crashing sound of a metal plate when struck with a bar. Therefore it is quite probable that these spiders do not hear at all.

2. It might be supposed that possibly this extreme quiescence was itself an indication that the spiders perceived the tones and responded in this way; however the fact that these spiders

remain motionless in their cages for hours together seems to prove that the sound is not perceived in any measure, or at least that it produces no response. All parts of the body are extremely sensitive to touch and the spider responds immediately if it or the cage comes in contact with the vibrating tuning fork.

3. Males and females respond exactly alike to stimuli of smell and hearing.

4. Pardosa responds normally to the essential oils by turning away, making vibratory movements with palpa and mandibles, and raising each leg as it is stimulated.

5. Individuals from which the palps have been removed respond to odors normally with each leg.

6. Individuals with the first pair of legs removed respond normally with the palps and the remaining three pairs of legs.

7. Spiders that have had the sense hairs cut off or sand-papered respond as do normal specimens.

8. Specimens with the tarsal joint cut from each leg respond as usual by raising each leg when stimulated.

9. From the foregoing results it seems quite evident that the ability to perceive odors is distributed over the whole integument of the spider and there is no definitely localized olfactory organ.

The work for this paper has been done entirely under the direction of Dr. T. H. Montgomery, Jr., and the writer is indebted to him for many valuable suggestions as well as sympathetic interest and encouragement.

BIBLIOGRAPHY.

BERTKAU, P.

'85. Ueber die Augen und ein als Gehörorgan gedeutetes Organ der Spinnen. Situngsb. Niederrhein. Ges. 1885.

CAMPBELL, F. M.

'80. Observations on Spiders. Hertfordshire Nat. Hist. Soc. I.

DAHL, F.

'83. Ueber die Hörhaare bei den Arachniden. Zool. Anz. VI.

DAHL, F.
'84. Das Gehör-und Geruchsorgan der Spinnen. Arch. mikr. Anat. XXIV.

DAHL, F.
:03. Ueber das System der Spinnen. Sitzungs-Berichte der Gesellschaft naturforschender Freunde. Jahrg. 1904, Ar. 5.

GAUBERT, P.
'90. Note sur les Organs Lyriformes des Arachnides. Bull. Soc. Philom. (8) II.

GAUBERT, P.
'92. Recherches sur les organs des sens et sur les systèmes, integumentaires, glandulaires et musculaires des appendices des Arachnides. Ann. Sci. Nat.

MCCOOK, H. C.
'90. American Spiders and their Spinning Work. Vol. II. Philadelphia.

MENGE, A.
'43. Ueber die Lebensweise der Arachniden. Neueste Schr. Naturf. Gesell. Danzig. 4.

MONTGOMERY, T. H., Jr.
:03. Studies on the Habits of Spiders, particularly those of the Mating Period. Proc. Acad. Nat. Sc. Phila.

PECKHAM, G. W. AND E. G.
'87. Some Observations on the Mental Powers of Spiders. Journ. Morph. I.

POCOCK, R. I.
'93. Further Notes and Observations upon the Instincts of some common English Spiders. Nature XLIX.

AMITOSIS IN THE EMBRYO OF FASCIOLARIA.

HENRY LESLIE OSBORN.

A NUMBER of years ago, while studying the embryology of Fasciolaria, I noticed evidences of amitosis in three different locations. As biological opinion has not reached a state of rest in regard to amitosis and its relation to mitosis, I have felt that a study of the facts in this case would perhaps prove of interest. A few brief references to the literature of the subject will show the unsettled condition of public opinion in this matter. Waldeyer ('90) said that "nuclear division is a single process with Remak's simple amitotic division as the fundamental form." Johnson ('92), on the contrary, said that he was "convinced that it (amitosis) is not derived from mitosis, and on the other hand is not a forerunner of the more complicated process." Johnson considers it a different type which along with karyokinesis has been transmitted from the simplest forms of life to the most highly organized. Nor is there unanimous consent as to the significance of amitosis. The bulk of observation is to the effect that mitosis is found in growing (*i. e.*, regenerative) tissue and amitosis is found in senescent, metabolic or pathologic tissue. In 1891 Ziegler contended that amitosis is due to senescence or highly active secretory action in cells, and vom. Rath ('94) espoused this view and defended it strongly. According to these writers amitosis is never regenerative (*i. e.*, found in developing tissue), but seals the fate of a nucleus which can never subsequently divide mitotically. E. B. Wilson in his work, *The Cell*, appears to be less favorably disposed to accept this view in the 1900 edition of his work than in the edition of 1896; in the 1900 edition he says that the view is "too extreme," though "there can be no doubt but that Flemming's hypothesis in a general way represents the truth, and that in the vast majority of cases amitosis is a secondary process which does not fail in the generative series of cell-divisions."

Some observations exceptional to this law may be briefly cited. Frenzel ('85) found in the intestine of certain decapods that the epithelium is regenerated from basal cells which show all stages of amitosis, while in other closely related genera the growth is from mitotic nuclei. Wheeler ('89) found that in the early blastoderm of Blatta all the nuclei divide amitotically at a certain stage, and that this is followed later by mitosis. Goppert ('91) found amitosis in the leucocytes of the salamander's liver which he regards as regenerative. Verson ('91) found that in the testis of the silkworm single large nuclei divide amitotically while their daughter cells give rise to spermatocytes mitotically. Meves ('91) found that in the salamander certain of the cells of the testis divided amitotically in winter and mitotically in summer. Preusse ('95) found mitosis in the youngest egg compartments of the ovaries of hemiptera, which consist of only a few cells and where active cell multiplication must be taking place. This writer cites observations of Carnoy and Claus in support of his claim that amitosis is regenerative in some cases. Pfeffer ('99, Wilson, :00) found that if "spirogyra be placed in water containing 0.5–1.00% of ether active growth and division continue, but only by amitosis. If, however, the same individuals be replaced in water mitotic division is resumed and an entirely normal growth continues."

These various observations upon amitosis all indicate a close relation between amitosis and mitosis. The fact that nuclei divide in one way in winter and in the other in summer, that in one genus one method prevails and in another related genus the other, and that mitosis can be replaced in the same cell by amitosis under the influence of ether, all of them suggest a process at bottom the same but operating differently under the influence of different circumstances. If so, we should regard amitosis as the more primitive mode and mitosis as a more highly specialized mode derived from it. And we need not then be surprised if the more primitive mode should occasionally occur in a place where on general principles we should look for the more highly specialized one. Though we generally find cell multiplication to be associated with mitosis and special metabolic activity to be associated with amitosis, we might in special cases find that cells

were multiplying by amitosis, the simpler mode having been adopted for local reasons.

The material on which this paper is based was collected at Beaufort, North Carolina (Osborn, '85), and preserved in either cold aqueous corrosive sublimate, picronitric or chromic acid solution. Sections were cut serially and stained on the slide in borax-carmine, in the days before iron-hæmatoxylin had been

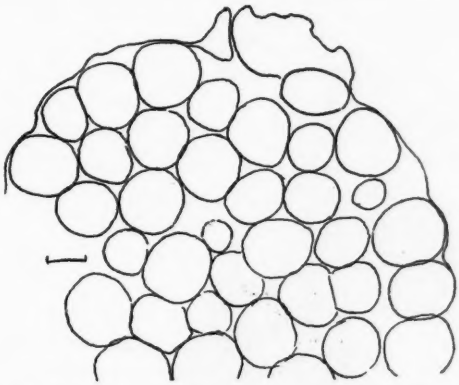


FIG. 1. — Section of embryo in plane of the throat, showing the very thin ectoderm, partial endoderm and food-ova. Scale 0.1 mm., cam. luc. × 60.

discovered. I should have been glad to check these results by more recent methods had access to fresh material been possible; however, the technique is fairly adequate for my purpose, as shown by the condition of the mitotic nuclei present and many other delicate cytological details. A brief account of the structure of the embryo will facilitate orientation, especially as this form is considerably aberrant. My studies at Beaufort were broken off before I had gotten the earliest stages. Sections of my earliest embryo are shown in Figs. 1 and 2. It is already past the gastrula stage, and consists of an extremely attenuated ectoderm enclosing a great number of small spherules each of approximately 0.15 mm. in diameter. There is a throat and a small amount of ectoderm, not nearly enough to enclose the spherules. The spherules are made up of a small mass of cyto-

plasm and a great many yolk granules enclosed by a sharp cell wall. In the centre of the cytoplasm there is a nucleus or more than one. These structures are not the ordinary yolk cells resulting from segmentation of the endodermal part of the original ovum, but according to MacMurrich ('87) they are unfertilized ova which were discharged into the egg capsule by the mother at the time of its formation together with the true eggs. He says "each egg capsule contains a large number, perhaps two hundred, of ova measuring about 0.25 mm. across; of these

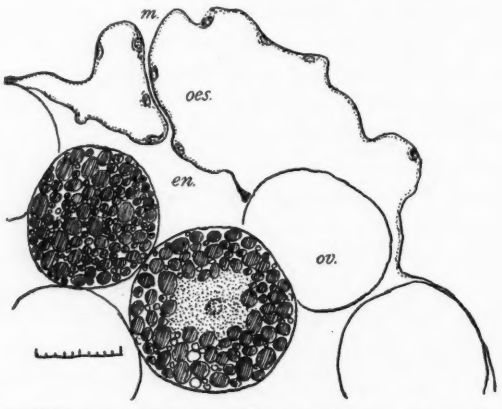


FIG. 2. — More highly magnified view of part of figure 1, scale 0.1 mm., cam. luc. × 430.

only four or six ever develop, the rest being swallowed by the developing embryos and used as food. The non-developing ova do not ever segment nor push out polar globules, nor do they break down or disintegrate, but are ingested by the embryos so that at an early stage one of these appears to consist of a large number of ova bound together into a ball." The embryo of Fasciolaria is thus very unlike that of related prosobranchs such as Nassa, in which the yolk is a part of the original structure of the egg cell, and hence part of the endoderm of the embryo, while in Fasciolaria the egg segments and reaches the gastrula stage and then swallows the other eggs itself having no supply of food. The ova thus swallowed I shall call food ova.

The larval kidneys are conspicuous organs in many proso-

branch embryos, but they do not reach such large dimensions or become such conspicuous objects in any other described forms as in Fasciolaria. They are called "sub-velar masses" in my paper of '85, and are shown in Figs. 1, 2, 3, 4, and 5. They are very early of development and are already conspicuous organs when the shell gland first shows. The velum subsequently arises and spreads out over them. In the earliest embryos the ectoderm cells of the area on each side of the mouth undergoes a peculiar change (Fig. 3), the boundaries of the cells cannot be seen, vacuoles of various sizes appear in the cytoplasm, and some of the larger vacuoles push the nuclei aside compressing the nucleus, much as in the fat cells of vertebrates. This is the first step in the development of the larval kidney. The nuclei at this time still show mitosis, two of the cells of the figure are in stages of active karyokinesis, there is no evidence as yet of amitosis. As the accumulation of material within the cell goes on, the outer end is pushed up above the general level of the ectoderm and becomes the swollen organ we see. The cells become wedge-shaped, each retains its place on the ectoderm by its base, the cytoplasm is pushed out into the outer end of the cell, which becomes rounded there as if through the influence of pressure from within. The content of the cell is chiefly a material which in life is fluid and highly refractive, but it is coagulated by preservative reagents; it is faintly stainable and not dissolved by absolute alcohol or oil. The cytoplasm at the outer end of the cell (Fig. 4) contains one or more nuclei. The relation of the cells to the general ectoderm is shown in Fig. 4; the organ is considerably constricted at its base.

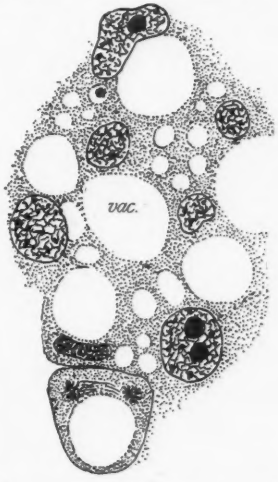


FIG. 3.—Surface view (tangential section) of ectoderm at one side of the mouth, showing first stages in the formation of the larval kidney.

There are no evidences of cell division among the older cells;

additions are evidently made at the periphery of the organ at the expense of the ordinary ectoderm cells. But though the older cells are not dividing, there are many of them in which the cytoplasm at the outer end contains two nuclei, so that we infer that nuclear division has been going on. No mitotic figures are to be found in these cells but there are evidences of amitosis. Fig.

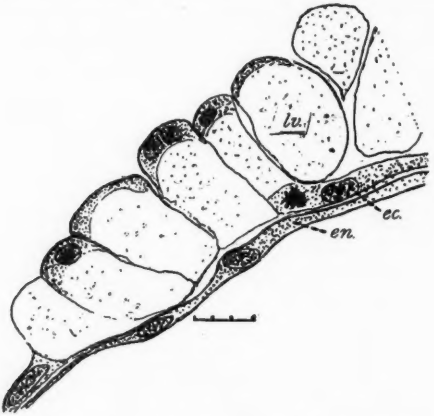


FIG. 4.— Section of the larval kidney at a later stage than figure 3, showing the ectodermal cells greatly enlarged by the secreted material, and the cytoplasm occupying the outer end of the cell, cam. luc. × 211. Scale = .01 mm.

5 shows three stages of this: in the lower figure the initial constriction, in the middle one the completion of the division, and in the upper one the two nuclei have moved apart.

The physiological significance of this organ is indicated by its name. As usual with prosobranchs, the embryo develops inside an impervious capsule; consequently it is of great importance that the wastes from its actively developing tissues be kept out of contact with them. This is done by intracellular storage. The barrier of living cytoplasm at the outer end of the cell keeps the cell the better from disintegrating there and the contained material from escaping. This device reminds one of the lepidoptera and their scales as reservoirs for waste nitrogen during metamorphosis.

Amitosis here is clearly in accordance with the view that senescence and amitosis are closely related, for these cells are

plainly reaching the end of their career. Though they are for the time a part of a very young embryo, the organ is no more an integral part of the embryo than are the embryonic membranes of arachnids and insects, in which amitosis is well known to be associated with senescence. It is really merely an embryonic structure. It is not, however, clear that the active secretory function of these cells is a cause of the amitosis. If it were we should expect that in cells where it was taking place as actively as in the one in Fig. 3 at the bottom of the drawing should show amitosis, whereas it and the one over it are dividing amitotically.

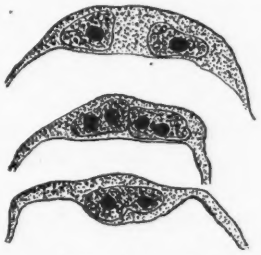


FIG. 5. — Outer ends of three cells from same situation as figure 4, showing nuclei in different stages of division, cam. luc. × 600.

The food-ova present nuclear appearances of sufficient interest to deserve mention. In the earliest embryos (Figs. 1, 2) they are intact and still manifest cell activities of their own notwithstanding their having been swallowed as food. Each has a definite egg-membrane enclosing a mass of cytoplasm often located near the surface of the cell, its branches reaching out among the very numerous grains of yolk. Many of these ova exhibit peculiar nuclear activities. In some one finds a single nucleus near the centre of the cytoplasm of large size and containing within its membrane not the more customary chromatine network but instead a mass of bubbly material (fig. 6) as if the chromatine had been converted into a froth. Other cases are met in which there are numerous small nuclei, as in Fig. 8.

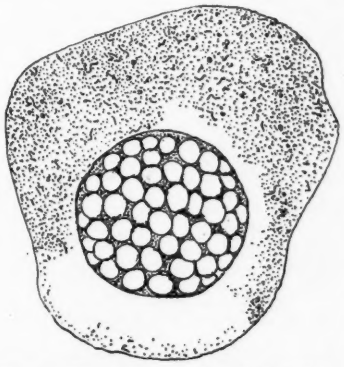


FIG. 6. — The nucleus and immediately adjacent cytoplasm of one of the food-ova, vacuolated condition of the nucleus, cam. luc. × 600.

In such cases the centre of the protoplasmic area often contains a somewhat more deeply stained material not limited by any distinct boundary from the general cytoplasm, but occupying the position of the single nucleus of other ova and having the same size, and the cytoplasm often radiates from this as a centre of influence. The lesser nuclei do not usually show active division, but are in the resting stage. They show evidences of disorganization in various respects. Some are distinctly vacuolated as the parent nucleus was; others contain bits of chromatine of no regular shape or position, resembling very closely the "spore-like bodies" found by Herrick ('92) in the "degenerating nuclei" of the yolk cells of the egg nauplius of Alpheus. In a few instances two of these smaller nuclei are still connected by a thread of stainable material, as in Fig. 7, which I interpret as the last stage in amitotic division, and an indication of the proc-

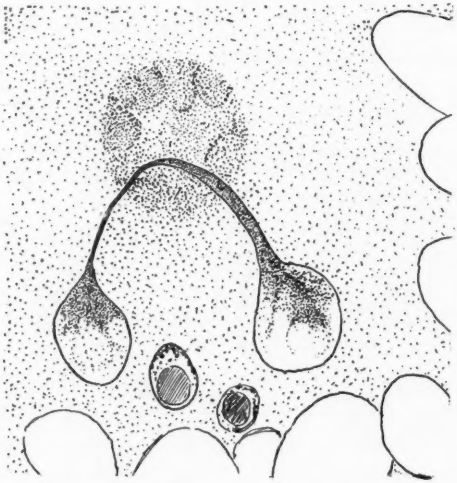


FIG. 7.— Nuclei and surrounding cytoplasm, showing the last stage in a nuclear division, cam. luc. × 600.

ess by which the multiple nuclei of the food-ova have been formed. The cells in which the nuclei have undergone these changes are on the road to complete breakdown and these changes are the last events in their lives. The process is a

futile attempt at segmentation where normally we should find mitosis, but in this case the cell having the impulse to divide but being powerless to do so by mitosis falls back on the easier mode and does so by amitosis. We may call it cell senescence.

The gastrulas before they have swallowed the food-ova are (according to information and drawings access to which I owe to the kindness of Prof. MacMurrich) very queer looking objects on account of the very ample folds of the ectoderm to allow for the distension which is to follow. One would expect that the endoderm would be equally so, in order to receive the ova into an endoderm-lined cavity, but after much study of this point I am convinced that unusual as it is there is not enough endoderm to enclose these ova, but only a very small amount reaching out a short distance from the throat in all directions, as in Fig. 2.

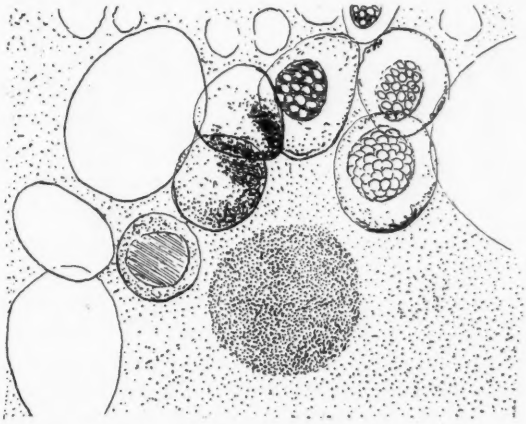


FIG. 8.— Multi-nucleate condition of older food-ovum, the nuclei showing vacuolation, cam. luc. × 600.

A study of various series agrees in showing only one very thin layer the ectoderm in contact with the ova except near the stomodæum. As development progresses the endoderm pushes out around the food-ova, at first with very thin flat cells, which later still become cubical and finally differentiate into the large and vacuolated definitive cells of the liver, or the columnar cells

of the intestine. During the early part of this process, while the endoderm cells are still flat or cubical, and before their final differentiation has taken place, their nuclei exhibit unmistakable evidences of amitosis. Fig. 9 is taken from such an embryo. The food ovum, part of which is shown in the figure, is still intact; it has not yet undergone the breakdown of structure which is soon to take place. The endoderm is composed of

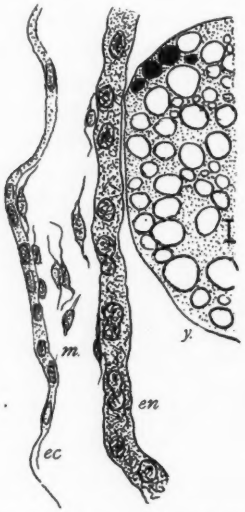


Fig. 9. — Section vertical to the ectoderm and underlying endoderm in very young embryo, scale = .01 mm., cam. luc. × 211.

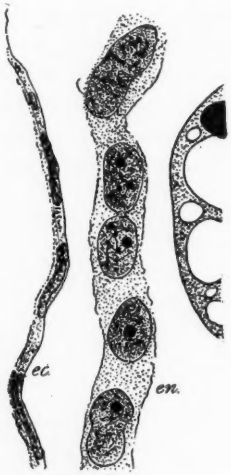


FIG. 10. — More highly magnified view of part of fig. 9, × 600.

cubical cells in which dividing nuclei are to be seen. The endoderm cells do not show any walls at this time between the cells but has the appearance in this view and in surface views of a syncytium. Walls appear at a later date and distinct cells are clearly seen in older embryos. A more highly magnified view of the cells of Fig. 9 (Fig. 10) shows nuclei at different stages of amitotic division. These views are very characteristic and found in many different places in several series of embryos of this age. They are further corroborated by flat views from places where sections are cut tangentially through the endoderm (Fig. 11), in which the syncytial character of the layer is

shown. Large nuclei of irregular shape (Fig. 12) are also found in the endoderm of this stage; they are apparently also forms of amitotic division. Their exact relation to the more typical cases could not be determined from the material which I had. They are quite commonly to be found in embryos of a little older stage but before the endoderm has assumed its definitive form. Nuclei of both these forms predominate decidedly during the development of the embryo, but in addition to them there are occasional nuclei showing unmistakable karyokinetic figures. The latter are too infrequent to be regarded as the nuclei from which the rapidly growing endoderm is being chiefly regenerated, but there is nothing to show that they do not give rise to endoderm cells as well as the amitotic nuclei. The presence of the mitotic figure is a guarantee of the adequacy of the technique, whatever we may think of the amitosis in these cases, at least it is not possible to dispose of them as artifacts. We recall in this connection the cases of amitosis in the intestinal cells of isopods observed by Ryder and Miss Pennington, as referred to by Conklin ('97). These were shown by him to be artifacts due to pressure in manipulation and resultant distortion. In that case the amitosis was in adult cells and the pressure was brought about by instruments and not in embryonic tissue and in a course of nature. The food-ova do not compress the endoderm, for at the time they are swallowed the layer has not as yet been formed; they grow out into the cavity after the ova have been swallowed. After a study of the available material I have not been able to resist the conviction that in Fasciolaria we find a true case of embryonic cells multiplying, contrary

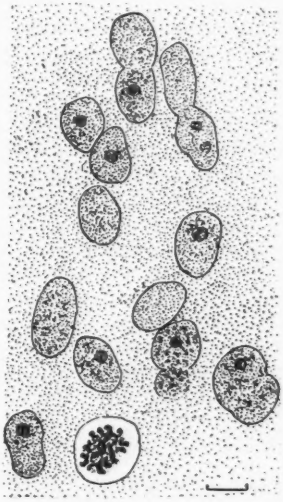


FIG. 11. — Surface view (tangential section) of part of endoderm, showing nuclei in direct division. Scale = .01 mm., cam. luc. × 600.

to the very general rule, by amitosis. A renewed study of this and kindred forms with reference to this point is much to be desired.

These cases of amitosis are sufficiently out of the common order to require a further study in the light of the general principles relating to the amitosis question. That of the larval kidney could perhaps be attributed to senescence but hardly to metabolism, since cells are found dividing by mitosis after secretory activity has been going on to such an extent that the nucleus is distorted and crowded into one side of the cell. The cells after they have reached a stage in which amitosis is found have apparently reached the end of their career and do not multiply further; that is, they are senescent.

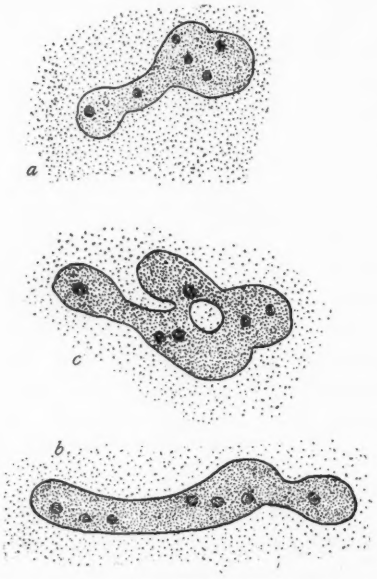


FIG. 12. — Nuclei in the endoderm, plasmodial type, cam. luc. × 600.

It is highly remarkable that the food-ova nuclei should not divide mitotically, for the food-ova are to be interpreted as unsegmented eggs. The divisions of the nucleus in ordinary eggs both in maturation and segmentation are mitotic, and we are justified in expecting karyokinesis of the food-ova nuclei. But instead their nuclei are queer from the first and seem to divide amitotically. This amitosis cannot be assigned to either senescence or metabolism, the cells show no signs of secretory activity, and are not senescent. The case of Spirogyra, according to Pfeffer, and of the salamander, according to Meves, are somewhat analogous in that

in both of them mitosis has been replaced by amitosis through the influence of an extraordinary circumstance, cold weather or ether. We know of no parallel to the case of the food-ova among the gasteropods. In the trematodes the yolk cells of the egg are perhaps somewhat similar; their nuclei do not divide at all.

The nuclei of the young endoderm are also out of the ordinary course. We should expect them to divide by mitosis. While in a small percentage of cases they do divide in that manner, in most cases the indications are strongly in favor of amitosis. Here neither senescence nor metabolism can be the cause of the amitosis. The cells have not yet arrived at their definitive form, much less become old, and secretion has not yet commenced; but, on the contrary, the cells are actively multiplying, so that they quite contradict the theory proposed by Ziegler and vom Rath.

We see, then, that while the amitosis of Fasciolaria can be attributed to senescence in one case, it cannot be attributed to either senescence or metabolism in the other two cases; and in the endoderm the amitosis is even regenerative. We have seen that senescence and metabolism cannot be regarded as causes in certain other instances of amitosis, such as those reported by Fresnel, Meves and Pfeffer. Upon the hypothesis that mitosis and amitosis are independent and non-related processes, cases of this sort are wholly unintelligible, and consequently indicate a defect in the hypothesis, if not that it is erroneous. It is true that we do not find intermediate modes of nuclear division between mitosis and amitosis, and yet *à priori* we should suppose them to be related and mitosis to have been derived from amitosis. The exceptions that are being found are all of them cases in which mitosis would be looked for and amitosis is found. The frequency of mitosis in embryonic tissue does not prove that embryonic tissue cannot multiply by amitosis; it only shows that there is some reason why in most cases it does not. Since mitosis is such a delicately adjusted and complicated process, may we not suppose that a nucleus to be capable of it should be in the best possible condition, — that is, young and vigorous, — and to that end that the surrounding conditions

should be as favorable as possible? And may we not further suppose that in the presence of conditions lowering the vigor of a nucleus, even if it were in a case where we should ordinarily expect mitosis, it would then revert to the more primitive mode of amitosis? We are not unfamiliar with the principle of physiological reversion in organs and tissues. Can we extend the principle to nuclei? If so, all the cases where amitosis occurs in a place where mitosis is expected to occur would perhaps be capable of being brought within its scope. Possibly both senescence and secretion as causes of amitosis could be interpreted in the same way. Thus senescence as a cause of amitosis, as it undoubtedly is, would be in reality due to the lowered vitality of the cell consequent on age. Metabolism perhaps could be supposed to cause it, where there is not at the same time, as in fat cells, milk cells and others, senescence, through the presence of the secretion which may exercise an unfavorable influence on the nucleus chemically. Pathologic tissues would also find an easy explanation on this basis to account for the common occurrence of amitosis in them. Summer by inducing optimal well-being of the cell would put it in condition for mitosis; winter by lowering its vitality would render it unable to divide by mitosis but not by amitosis. Pfeffer's observation on the effect of ether would also fall in line, the cell tending to divide by mitosis but being prevented by the interference with its powers consequent on the influence of the ether. In Fasciola the larval kidney cells while young still divide by mitosis and are consequently vigorous, notwithstanding the presence of considerable metabolic material, but as they become old they lose this power and divide by amitosis. The food-ova with their tendency to mitosis are placed in conditions so unfavorable to their well-being that cell division does not take place at all and nuclear division is only by amitosis. The deeply staining granular particles in some of them may be imperfectly formed chromosomes, as if mitosis had been attempted but without success. A careful cytological study of these food-ova would be very likely to repay study, as it might throw light on the relation between the two modes of nuclear division. The endoderm cells are developing in the amitotic manner and this is the chief

mode by which the embryonic gut enclosure is taking place, if not the only mode. In their case neither senescence nor metabolism can be urged as the cause of the amitosis. Under ordinary circumstances we should find the endoderm increasing by mitosis, but here the mode of growth is very extraordinary, and the case only finds explanation on the principle I have been indicating. I do not know just what particular cause should be assigned in the case of the endoderm, which is to be considered as interfering with the mitosis; perhaps it is the pressure conditions existing in the enteron owing to the presence of such a large amount of inert and foreign matter; perhaps it is the absence of the most favorable food for the endoderm, since the food-ova have not yet begun to be consumed.

Note.— Since revising the last proof of this article, the writer has read with interest a passage in Dr. Davis' article (Am. Nat. 38, p. 434) containing much the same idea vid.— "It is possible that direct division in the higher plants is in a sense a reversion to early ancestral conditions, a reversion *that comes on only when for some reason the normal activities of the germ cell are in abeyance or have ceased.*"

BIBLIOGRAPHY.

BROOKS, W. K. AND HERRICK, F. H.

'92. The Embryology and Metamorphosis of the Macroura. Mem. Acad. Nat. Sci., vol. 5.

CONKLIN, E. G.

'97. The Relation of the Nuclei and Cytoplasm in the Intestinal Cells of Land Isopods. Am. Nat., vol. 31.

FRENZEL, J.

'85. Ueber den Darmkanal der Crustaceen nebst Bemerkungen zur Epithelregeneration. Arch. f. mik. Anat., vol. 25, p. 137.

JOHNSON, H. P.

'92. Amitosis in the Embryonal Envelopes of the Scorpion. Bull. Mus. Comp. Zool., vol. 22.

MACMURRICH, J. P.

'87. A Contribution to the Embryology of the Prosobranch Gasteropods. Biol. Stud. Johns Hopk. Univ., vol. 3.

MEVES, F.
'91. Ueber amitotische Kerntheilung in den Spermatgonien des Salamanders. Anat. Anzeig., 6.
OSBORN, H. L.
'85. Development of the Gill in Fasciolaria. Biol. Stud. Johns Hopk. Univ., vol. 3.
PFEFFER,
'99. Ueber die Erzeugung und Physiologische Bedeutung. der Amitose. Ber. koenigl. sachs. Ges. Wiss. Leipsig.
PREUSSE.
'95. Ueber die amitotische Kerntheilung in den Ovarien der Hemipteren. Zeit. f. w. Zool., vol. 59.
VERSON, E.
'91. Zur Beurtheilung der amitotischen Kerntheilung. Biol. Cent., vol. 9.
VOM RATH, O.
'91. Ueber die Bedeutung amitotische Kerntheilung im Hoden. Zool. Anz., vol. 14.
'94. Beit. z. Kent. der Spermatogenesis von Salamandra maculosa. ii, Theil, Die Bedeutung amitosis, etc. Zeit. f. w. Zool., vol. 57.
WALDEYER, W.
'90. Karyokinesis and its Relation to Fertilization. Q. Jnl. Mic. Sci., vol. 30.
WHEELER, W. M.
'89. The Embryology of Blatta and Doryphora. Am. Jnl. Morphol. vol. 3.
WILSON, E. B.
:00. The Cell in Development and Inheritance. Columbia Biological Series.
ZIEGLER, H. E.
'91. Die biologische Bedeutung der amitotische Kerntheilung im Tierreich. Biol. Cent. vol. 11.

BIOLOGICAL LABORATORY OF HAMLINE UNIVERSITY,
SAINT PAUL, MINN.
April 25, 1904.

THE TRANSPLANTING OF TROUT IN THE STREAMS OF THE SIERRA NEVADA.

DAVID STARR JORDAN.

THE rivers of California contain four well marked species of trout: (1) The rainbow trout, *Salmo irideus*, in the streams of the Sierra foothills, and in all the streams of the coast range; (2) the steel-head trout, for which the oldest and therefore correct name seems to be *Salmo rivularis*, rather than *Salmo gairdneri*. This is found in the coastwise streams only, whence it runs regularly to the sea, the rainbow trout running only when the sea is conveniently near; (3) the cut-throat trout, *Salmo clarki*, found only in the streams of the northern and northwestern counties; and (4) the Tahoe trout, *Salmo henshawi*, a derivative of the cut-throat found on the east flank of the Sierras, in the tributaries of the extinct Lake Lahontan.

Subspecies or variants have developed from these, especially from *Salmo irideus*. The typical rainbow trout is found in the streams about San Francisco Bay. A slight variant called var. *shasta* is found in the upper Sacramento and in the northern Sierras. With it, but rare, is var. *stonei*, the Nissui trout. In the Kings and Kern rivers is the smaller scaled variety, *gilberti*, and from *gilberti* is descended the dwarf golden trout, var. *agua-bonita*, found only in Volcano (Whitney) Creek on the banks of Mount Whitney, above the high waterfall sometimes called Agua Bonita. The typical Tahoe trout, *Salmo henshawi*, spawns in the streams, but in the depths of the lake is a well marked subspecies of large size spawning in the lake, called var. *tahoënsis*.

The distribution of these species is well made out, but certain anomalies were noticed, especially in the distribution of the Tahoe trout. All these anomalies have been found to be due to transplanting by the hand of man. For the benefit of future students of trout I place these facts on record.

The Stanislaus, Tuolumne and Mokelumne Rivers flowing westward from the Sierra Nevada had in the early days no trout above the falls in their cañons. To these streams the trout were carried over the Divide, and the Tahoe trout is now abundant in the upper waters of these rivers.

For the details of the transplanting of these trout I am indebted to the kindness of Mr. H. S. Blood of Angels, the owner of Bear Valley, at the head of the north fork of the Stanislaus, on the "Toll Road" from the Calaveras Big Trees to Carson Valley.

The earliest plant was made in 1859, the Tahoe trout having been taken from Hope Valley, on the east slope of the Sierras, by the Union Water Company to stock their reservoir at the head of the north fork of the Stanislaus.

In 1861, Abram Ritchie of Big Trees and John Christy of Jenny Lind brought Tahoe trout from Hope Valley and planted them in the head waters of Mokelumne River.

In 1863, H. S. Blood of Angel's and J. C. Curtis of Murphy's brought Tahoe trout from Wolf Creek, Carson Valley, and stocked Highland Lakes, at the head of the Stanislaus.

In 1864, O. S. Boardman of Galt took Tahoe trout from Hope Valley, planting them in the Blue Lakes, near the head of the Mokelumne. At about the same time H. S. Blood, Mark M'Cormick and Herman Tyrie stocked Highland Creek with Tahoe trout from Hope Valley.

The middle fork of the Stanislaus was stocked with Tahoe trout from Walker River, Nevada.

In 1873, Joseph Emery of San Francisco, brought trout from the north fork of the Mokelumne, stocking the Blue Lakes of Amador with the Tahoe trout.

The Tahoe trout was planted in Feather River by Mr. Pratt, founder of the village of Prattsville in Plumas County, the fish being taken from Truckee River.

The golden trout, *agua-bonita*, has been taken from Volcano Creek and successfully planted in Lone Pine Creek, on the east side of the Sierra Nevada.

The rainbow trout, var. *shasta*, has been planted by the State Fish Commission in the Truckee River, where it is now abun-

dant. With it was taken the Sacramento perch, *Archoplites interruptus*. The present writer lately obtained a small specimen of this species from an Indian ditch at Wadsworth, Nevada.

The eastern brook trout, *Salvelinus fontinalis*, has been planted in many California streams, which it seems to find congenial.

A NEW SPECIES OF DIAPTOMUS FROM MEXICO.

A. S. PEARSE.

Diaptomus lehmeri, n. sp.

Cephalothorax, broadest at the middle; with four distinct sutures. The last segment, produced laterally and armed with two prominent spines. The first segment of the abdomen, armed on each side with a strong sharp spine. The first segment of the female abdomen is tapering and about as long as the remainder of the abdomen. The second segment is short, being only one-fourth the length of the third. The furcal rami are almost twice as long as broad, and hairy on both margins in the female (Fig. 1), but on the inner margin only in the male.

FIG. 1.—*Diaptomus lehmeri* n. sp. Abdomen of female × 87.

Antennæ twenty-five segmented and reaching beyond the tips of the furcal rami. The right male antenna (Fig. 4) is moderately swollen and its antepenultimate segment bears a pointed curved hook, which is not as long as the ultimate segment.

FIG. 2.—*Diaptomus lehmeri* n. sp. Fifth feet of male × 205.

The male fifth feet (Fig. 2) are rather robust. The first basal segment of the right foot has a tubercle near its outer margin which bears a long sharp spine. The second basal segment is almost as

broad as long and besides the usual hair on the outer margin it is provided with a characteristic process on its posterior surface. There is a small hyaline projection on the distal margin of this segment and also on that of the first segment of the outer ramus. The first segment of the outer ramus is very short, being one-third as long as the second segment and is produced into a tubercle at its outer distal angle. The second segment has a large tubercle on its posterior surface. The marginal spine is strong, but slightly curved, longer than the segment, two-thirds the length of the terminal hook, and is roughened on its inner margin. The terminal hook is strong, arcuate and minutely denticulate at the middle of its inner margin. The inner ramus is one segmented, short, (about as long as the first segment of the outer ramus) and hairy at the tip.

FIG. 3. — *Diaptomus lehmeri* n. sp. Fifth foot of female × 205.

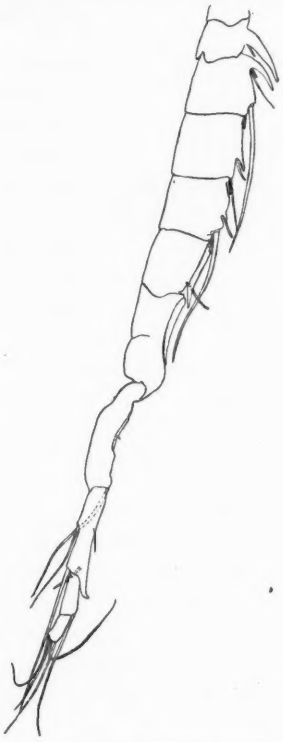


FIG. 4.— *Diaptomus lehmeri* n. sp. Tip of right antenna of male × 128.

In the left male fifth foot (Fig. 2) the first basal segment is armed with a tubercle and spine like that of the right. Second basal segment is three-fourths as broad as long and bears the usual hair on its outer margin. First segment of the outer ramus curved on outer margin, the inner margin notched and ciliated. The terminal segment is triangular and ends in a blunt process and proximad to this is a slender hair; the

inner surface is ciliated. The inner ramus is short and hairy at the tip.

The female fifth foot (Fig. 3) bears a large tapering spine at the outer distal angle of the first basal segment. The second basal segment is triangular and provided with the usual lateral hair. The outer ramus is three segmented. The first and second segments are about equal in length. The second segment is tapering and along the center of its inner side is armed with strong teeth and is usually with two or three small teeth on the outside. The second segment has a short spine above the third segment. The third segment is small and is armed with a long and a short spine. The inner ramus is not half as long as the first segment of the outer ramus and is two segmented. The second segment is armed with two terminal spines with delicate hairs between them and a lateral spine on the inner side.

Length: Female 1.69–1.83 *mm.* Male 1.61–1.67 *mm.*

The specimens from which this species is described were collected by Mrs. Frank Lehmer, July 22 to August 7, 1904, in Mexico City, Mexico. It was apparently abundant at that time, as it occurs in most of the dredgings made.

This species was associated with *Cyclops viridis insectus* Forbes, *Cyclops albidus* Jurine, Canthocamptus sp.?, and an ostracod.

HYLA ANDERSONII AND RANA VIRGATIPES AT LAKEHURST, NEW JERSEY.

WILLIAM T. DAVIS.

On the 5th of last September while looking for insects near a swamp at Lakehurst in the pine barrens of New Jersey, the writer was fortunate in finding a specimen of the rare tree frog *Hyla andersonii* Baird. The frog was in a small oak tree standing but a few feet from the swamp. At the time Cope's work on "The Batrachia of North America" was published in 1889, but three specimens had been recorded, namely the type from Anderson, South Carolina; the one collected at Jackson, Camden Co., New Jersey, in 1863 by Leidy, and the third example found by Dr. John E. Peters at May's Landing, Atlantic Co., New Jersey on June first, 1888. A record of this last is to be found in the *American Naturalist* for January, 1889. In the *American Naturalist* for December, 1894, J. P. Moore gives an account of two of these tree frogs collected in June, 1889, at Pleasant Mills, New Jersey, and of the many others heard at the time. The frogs, however, disappeared shortly and no others could be found on subsequent visits to the locality. Lakehurst is considerably farther North than the three New Jersey stations mentioned above. It may be well to mention at this time that *Rana virgatipes* Cope, is also to be found at Lakehurst. The species was originally described from Cape May County, New Jersey.

According to Cope, in *Hyla andersonii*, "The green of the back and extremities is everywhere margined with pure white, except posteriorly on the femur and tibia, and anteriorly on the former where saffron takes its place." My living specimen, however, differs from this description and the colored figure, by having the band of pure white extend along the end of the body and a short distance on the posterior margin of each femur.

New Brighton, Staten Island, N. Y.

NOTES AND LITERATURE.

PSYCHOLOGY.

Natural Science and Psychology.[1] — For the convenience of those who do not have access to his "Grundzüge der physiologischen Psychologie" Prof. Wundt has reprinted under the above title the last two chapters of the third volume of his great work. In the space of a hundred pages there is given a clear statement of what the author believes concerning: (1) The logical foundations of natural science, (2) Mechanics and energetics, (3) Mechanism and vitalism, (4) Causality and teleology of the psychophysical life-processes, (5) The concept of mind, (6) The principles of psychical causality.

Of special interest to biologists are the discussions of mechanics and energetics, and of the mechanistic and the vitalistic theories. Such a book is valuable to most natural sciences in that it serves to call attention to the too much neglected presuppositions on which specialistic work in the natural sciences rests, as well as to the principles of the sciences. Wundt writes in a patient, plodding, persistent manner; his sanity is all the more evident because of the lack of any brilliancy of treatment.

In view of the appearance of this reprint it is worth while to notice the interest, especially among the German biologists, in the psychic "as an elemental factor in nature," as Driesch in a recent book has stated it. Whether one agrees with Wundt's conception of the relations of the physical and the psychical, with Driesch's, with Ostwald's, with Schneider's may not seem of much consequence to most students of natural science; nevertheless, there can be no doubt that only those who hold theories and see or seek principles can do more than assemble facts whose meaning is clear only in the light of the generalizations which are called laws. No one can study Wundt's book without gaining an interest in the various forms of organic processes that the mere search for facts would not give. To state the content of the book would defeat my purpose to arouse an interest which may lead many to the work itself.

ROBERT M. YERKES.

[1] Wundt, Wilhelm. *Naturwissenchaft und Psychologie.* Leipzig, 1903, 8vo, 126 pp.

"The Criminal Classes."[1] — Rev. D. R. Miller, D.D., has been chaplain of the Ohio Penitentiary and superintendent of the Girls' Industrial Home of Ohio. In "The Criminal Classes. Causes and Cures" he has collected material of various sorts connected with his service in these positions.

At the beginning, near the middle, and near the end of the volume, are chapters briefly treating in a general way the extent of crime, its cost to the community, causes of crime, and methods for the prevention of crime. These discussions are somewhat vague and commonplace and are not fully adjusted to the results of recent scientific study. This sentence from the chapter on "Innate and Psychological Causes" may serve as an illustration of the nonagreement with conceptions of present day physiological psychology: "Regarding moral conduct, in this class there seem to be indications of a broken or missing link between the brain tissues and the moral monitor." There are evidences also of lack of familiarity on the part of the author with recent literature in penology. For instance, he writes, "As agencies in the prevention of crime and the reformation of young criminals, too much importance cannot well be attached to the private and public institutions denominated 'Child-saving institutions,' 'Schools for the little ones,' and 'Homes for children.'" He then fails to mention the movement now in force in many parts of this country, which recognizes that care for children in institutions has not generally prepared them well for life outside of institutions, and which substitutes for the institutional method the methods of probation and placing out, that is, the supervision of the rearing of delinquent and dependent children, while they live as members of their own or other families. Many of the figures on which arguments are based are given without dates but as taken from books and reports now many years old. On the whole these general chapters cannot be said to give an adequate summary of facts known and theories held to-day on the topics which they treat.

A few chapters offer meagre outlines of the careers of noted criminals. Others give brief accounts of the lives and crimes of Ohio convicts. "In the introduction, however," as Dr. Miller says in the preface, "of these narratives, sketches, and illustrations, special care has been exercised to avoid sensational details of the crimes alleged because it is the opinion of the author that all such details serve as

[1] Miller, D. R. *The Criminal Classes. Causes and Cures.* Dayton, United Brethren Publishing House, 1903. 8vo, ix + 227 pp., portraits.

factors to turn into like crime those who may read them." Some of these chapters close with reflections, which, it must be said are in part obvious, in part without special applicability to the cases to which they are attached.

About half the chapters of the book are devoted to incidents that occurred in the author's experience as chaplain, and to writings by prisoners, in prose and poetry, on religious and other topics, some apparently sincere, others with a suggestion of cant. In religious work for the prisoner results can doubtless be gotten easiest by appeals which recall religious instruction received during childhood. At the same time nothing in a man's work as chaplain forces him to adapt himself to changes in religious thought in the world at large. It is natural, therefore, that the weight of the religious interest of the author should be, as it is, such as belongs with religious beliefs of a conservative type.

There is an introduction by Ex-Governor Foster of Ohio. A chapter by Professor Krohn of the University of Illinois compares criminals in whom strange combinations of traits are found with cases of double personality, but fails to call attention to some important differences.

Apparently Dr. Miller is a man who has done earnest and helpful personal work with the criminals placed in his care, but who in his devotion to his own special task has failed to gain the broad acquaintance with current thought in criminology and related subjects which would be needed for writing a very useful book on the causes and cures of crime.

ZOÖLOGY.

Fixation of the Eggs of the Crab. — Dr. H. Charles Williamson, in the 22d *Annual Report of the Fishery Board of Scotland*, adds considerably to our knowledge of the life history of the shore crab of Europe, *Cancer pagurus*. Possibly the most interesting is his discovery of the way in which the eggs are fastened to the swimmerets. These, like other eggs, have double envelopes, the outer chorion and the delicate inner vitelline membrane, and between these a small perivitelline space. When the eggs are extruded from the oviducts they pass into the brood chamber between the abdomen and thorax

and here are held in position by the exopods of the swimmerets while the endopods, covered by slender filiform hairs, extend into the mass of eggs. The pleopoda have powers of motion in two planes, one fore and aft, the other oblique. By these motions the ends of the hairs are brought in contact with the eggs which are thus penetrated by them, the hair passing in and out again. The egg itself rotates and escapes injury. In this way numbers of eggs are impaled or skewered on each hair. As development proceeds the chorion stretches and gives rise to a stalk, which increases in length with time. This process is also aided by the perivitelline fluid, which is adhesive and sticks the chorion to the hair. After the egg is hatched the egg shells and their stalks are cast off by molting the integument, the outer layer of the hairs, together with the adhering shells being cast with the rest of the 'skin.' The eggs are fastened only to the hairs of the endopods, as these alone are smooth and filiform. The hairs of the exopods are plumose or serrate, a condition which prevents their perforating the eggs.

Gardiner's Maldives.[1] — The third part of the second volume of Gardiner's Report maintains the unusually high quality of its predecessors. It contains six papers, of which three are written by members of the expedition and the three others by well known specialists.

The Isopoda are treated by Stebbing in 23 pages. Thirteen species are described, representing eight families. While some are from the sea at moderate depths, two (a Corallana and a Limnoria) are found in rotten wood in the lagoon, one (Cirolana) lives in tentacles of a large tubicolous polychæte. A Cymothoa lives on the gills of a parrot-fish. Tylokepon, n.g., is a bopyrid living on the gills of crustacea. Finally, a sphæromid (Exosphæroma) and a Ligia are representatives of two semi-terrestrial groups.

The Hydromedusæ are treated by Browne. The discussion of the Anthomedusæ leads to a revision of the family Williadæ with two genera, Willia and Proboscidactyla, of which the latter only is in the collection from the Maldives. It occurs also on the east coast of North America and has several species notable for their production of medusa buds. Among the Leptomedusæ is a five-rayed representative of Mayer's genus Pseudoclytia which Browne, following Mayer, believes to have arisen as a sport. The Trachomedusæ are treated in synoptic fashion. A new species and a new

[1] Gardiner, G. S. *The Fauna and Geography of the Maldive and Laccadive Archipelagoes, etc.* Vol. II, part III, pp. 589-698, pls. 35-48.

genus are created. Hermaphroditism is described in one case. One Narcomedusa, a long known species of the Indian Ocean, is described. Five species of Siphonophores were collected. The author states that he could find no copy of the Mark Anniversary Volume in London. Let him apply to Henry Holt & Co., New York.

The reptant decapods of the suborders Hippidea, Thalassindea, and Scyllaridea, are treated by Borradaile. The first two groups are taken between tide marks, the latter in the reefs or on sandy bottom. There are enumerated two albuneids and three hippids (Remipes), one axiid, a gebiid, four callianassas, two palinurids and one Scyllarus.

The Madreporaria are treated by Gardiner, who lays especial stress on their variation, distinguishing vegetative, continuous, and discontinuous or specific. This extensive paper is accompanied by well executed half-tone plates from photographs of the dry corals.

The Antipatharia are described in a few pages by Forster Cooper. They are chiefly Indian Ocean species.

The Arachnida of the archipelagoes, treated by Pocock, raise the question of their origin. "Some of the species, such as Isometrus europæus, Heteropoda regia and Uloborus geniculatus, which frequent human dwellings, have doubtless been introduced by human agency; but it is probable that the ancestors of the majority of the Spiders reached these islands on floating gossamer threads." "The presence of only one species of Scorpion [Isometrus europæus], and that a form notoriously liable to dispersal by man's instrumentality, suggests that, unless in very remote times, there has been no connection between the archipelagoes and the mainland of India . . . . and this is further borne out by the almost complete specific identity between the two faunas."

C. B. D.

CLIMATOLOGY.

Ward's Translation of Hann's Climatology.[1] — Dr. Hann, professor of cosmical physics at the University of Vienna and formerly director of the Austrian Meteorological Bureau, published in 1883

[1] Hann, Dr. Justius. — *Handbook of Climatology. Part I, General Climatology.* Translated by Robert DeCourcy Ward. The Macmillan Company, 1903. 8vo, 437 pages.

his *Handbuch der Klimatologie* which he reissued in 1897 in three volumes. This is the standard work on the subject of climate and no book in the English language is so authoritative or covers so wide a field. Consequently, Professor Ward's translation of the volume relating to General Climatology, which was made primarily for the use of his classes at Harvard University, confers a great boom on all American and English students of meteorology and physical geography.

In his title, Professor Ward has been too modest, for his book is itself revised and enlarged, considerable new matter relating to America having been substituted for certain topics which pertained more particularly to Europe. While it might be wished that this new material were distinguished from the author's German text, it is stated that all the additions have been approved by Dr. Hann, so that the translation is virtually a third edition of this part of the original work. Numerous references to recent periodical and other literature, in various languages, have been added and all the old references have been verified, so far as possible, by the translator. An added convenience is the summary of the contents of each chapter, while a copious index of subjects and authors facilitates looking up either. The metric system and the Centigrade scale of temperature are used throughout and should aid in familiarizing our students with these units, which are destined to supplant the English system in scientific writings. At present, however, the conversion tables in the Appendix will, no doubt, be found necessary by many readers. The German text has been accurately rendered into elegant English, and almost no typographical or other errors have been noted. As was said, only the first volume of Dr. Hann's work has been translated and this evidently possesses the most general interest, since the climatology of special regions, discussed by Dr. Hann in his other two volumes and consisting largely of statistics, can be more easily consulted by persons not familiar with the German language.

In conclusion, the reviewer expresses the hope that this admirable and disinterested work may have a wide circulation in our high schools and colleges and indeed among all English speaking persons who desire to understand the climatic conditions of the globe and their cause.

A. LAWRENCE ROTCH.

BOTANY.

Bog-Trotting for Orchids[1] is the title of a popular book dealing with the swamp flora of the Hoosac Valley. It gives a pleasant, diary-like account of the author's rambles for three seasons, in the course of which are given descriptions and other information regarding her various finds. An appendix of 44 pages presents a systematic account of the genera and species of New England Orchidaceæ, and there is an admirably full index. The illustrations are photographic, many of them excellent; some are colored, not always to advantage, and a considerable proportion are of landscape views or objects other than orchids. As one reads the rambling narrative one cannot but sympathize with the writer's enthusiasm, and is sure to get refreshing whiffs of out-door air. Despite occasional inaccuracies, showing the lack of expert revision, and the inclusion of considerable material of rather more personal than general interest, the book has the charm and value which belong to a faithful record of first-hand impressions, and which will doubtless render it an inspiring help to many amateurs.

F. L. S.

Agriculture for Schools.—Two interesting attempts to meet the demand for instruction in matters of special importance to farming communities, are found in a handbook of exercises edited by Prof. Hays[2] and an elementary text-book by Profs. Burkett, Stevens and Hill.[3]

The hand-book consists of 237 exercises of an eminently practical nature as may be judged from the following sample titles taken at random: Food stored in seeds; Making maps of public roads; Transpiration of water by plants; Teeth of domestic animals; Bowline knot; Sharpening pocket knives; Classes of chickens; Classi-

[1] Niles, Grace Graylock.—*Bog-Trotting for Orchids.* New York, C. P. Putnam's Sons, 1904. xiv + 310 pp., 72 pls.

[2] Hays, Willet M.—*Rural School Agriculture.* Bulletin No. 1. *Exercises in Agriculture and Housekeeping for Rural Schools.* St. Anthony Park, Minn., Department of Agriculture, University of Minnesota, 1903. 12mo, viii + 196, 79 figs.

[3] Burkett, C. W., Stevens, F. L., and Hill, D. H.—*Agriculture for Beginners.* Boston, Ginn & Company, 1903. 12mo, xii + 267, 215 figs.

fication of soils; Crossing corn; Emergencies; Removing ink from white goods; To make liquid yeast; Chicory in coffee; Cash account; Tent caterpillars; Planting trees; Farm gate lesson; Sewed seam; Overhand patch; Three-cornered darn; Cleft grafting. These exercises are arranged somewhat in the order of difficulty and in related groups, but the extent to which they shall elucidate principles or develop general ideas must very largely depend upon the teacher. If skilfully incorporated with other work and their bearings broadly discussed many of these exercises would have real educational value in fitting pupils to meet intelligently the actual problems of rural life.

The text-book proceeds in a more orderly way, establishing general principles and showing their application to problems of soil, culture, protection, selection, stock-raising and dairying. Suggestions for profitable observations or experiments are freely introduced. The illustrations are of unusual excellence, and the style clear and direct. Such a book cannot fail to advance the best interests of practical education in much needed directions. Both books might well be used together.

FREDERICK LEROY SARGENT.

Notes.— André Michaux's "Travels into Kentucky," F. A. Michaux's "Travels west of Alleghany mountains," and Harris's "Journal of a tour northwest of Alleghany mountains," are republished, with annotations, by Thwaites as vol. 3 of his series of *Early Western Travels*, issued by the Arthur H. Clark Company, of Cleveland. It is regrettable that the volume is not provided with an index making its wealth of detailed information available.

A small list of arctic plants is given in Schrader's "Reconnaissance in Northern Alaska," published as *Professional Paper No. 20* of the U. S. Geological Survey.

A polyglot suggestion of amendments to the Paris code of botanical nomenclature, addressed to the Vienna Congress of 1905, has been published by the botanists of the Gray Herbarium, the Cryptogamic Herbarium and the Botanical Museum of Harvard University, under date of June 9.

The annual species commonly referred to Polypteris have been segregated under Rafinesque's generic name Othake, by Bush, in vol. 14, no. 6, of the *Transactions of the Academy of Science of St. Louis.*

Three new exotic orchids ascribed to Rolfe are described by Ames in *Proceedings of the Biological Society of Washington*, of June 9.

Two new Jamaican species of Polypodium are described by Maxon in no. 1374 of *Proceedings of the U. S. National Museum.*

Blakeslee has an interesting note on the sexuality of Rhizopus in *Science* of June 3.

A paper on vitality and germination of seeds, by Duvel, forms *Bulletin no. 58* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

A résumé of ecological work in 1903 is given by Cowles in *Science* of June 10th.

A healthy sane tone pervades an article by Holt on the value of field and herbarium work in high school botany, published in *School Science* for June.

Ecological experiments on *Rumex Acetosella* are described by Transeau in *Science* of June 3.

A critical study of Lepidium is being published by Schinz in the *Bulletin de l'Herbier Boissier.*

A popular account of the native Papaw is given by Viola McCohn in *Country Life in America* for July.

A further list of Eastern species of Cratægus is published by Ashe, under date of June 15, in vol. 20, no. 2, of the *Journal of the Elisha Mitchell Scientific Society.*

Professor Bessey calls attention, in *Science* of June 24, to the early falling of the aberrant lowermost leaves of *Acer Negundo* each year.

The July number of *Arboriculture*, printed on paper made from the wood of Catalpa, contains data as to the availability of this wood for paper purposes.

A review of Californian Polemoniaceæ, by Jessie Milliken, forms vol. 2, no. 1, of the *University of California Publications, Botany*, issued May 10.

Heft 19 of Engler's "Pflanzenreich," is devoted to Betulaceæ, by Winkler.

An account of *Persea gratissima* as cultivated in Florida is published by Rolfs as *Bulletin no. 61* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

A developmental account of Juncaceæ is contributed by Laurent to no. 2–3 of the current volume of *Annales des Sciences Naturelles, Botanique.*

Anatomico-ecological studies of Tillandsia are published by Mez in Vol. 40, Heft 2, of *Jahrbücher für wissenschaftliche Botanik.*

The Germination of Amaryllidaceæ is considered by Worsley in the *Journal of the Royal Horticultural Society* of May.

A reprint of Bradbury's "Travels in the Interior of America," second edition, London, 1819, which forms vol. 5 of Thwaites' "Early Western Travels," contains a list of plants collected about St. Louis and on the Missouri River.

Under the title "Contributions to our knowledge of the flora of the Rocky Mountains," Aven Nelson has collected as a thesis for the Doctor's degree his more important papers published in various journals between 1898 and 1904.

The opening fascicle of vol. 5 of Urban's "Symbolæ Antillanæ" contains revisions of Smilax (by Schulz), Celastraceæ (by Urban), and Sapotaceæ, in part (by Pierre and Urban).

Under the heading "Trabajos de la Oficina de Historia Natural," the Colombian government is publishing a series of papers on the botany of that country, by Cortes.

The first fascicle of vol. 2 of Arechavaleta's "Flora Uraguayana," has been issued by the Museo Nacional de Montevideo, as a part of its *Anales.*

Volume 2 of Wood's "Natal Plants" is completed by the issuance of part 4, dealing with grasses.

No. 28 of the new series of "Contributions from the Gray Herbarium of Harvard University," forming vol. 40, no. 1, of the *Proceedings of the American Academy of Arts and Sciences*, and issued on July 18th, contains the following papers: Robinson and Greenman, Revision of the Genus Sabazia, Revision of the Mexican and Central American Species of Trixis, and Revision of the Mexican and Central American Species of Hieracium; Fernald, Synopsis of the Mexican and Central American Species of Alnus, and Some New Species of Mexican and Nicaraguan Dicotyledons; and Greenman, Diagnoses and Synonymy of Mexican and Central American Spermatophytes.

A companion to M. van den Bossche's "Icones Selectae Horti Thenensis" has been started, also with the botanical collaboration of de Wildeman and the delineating skill of d'Apreval, under the title "Plantæ Novæ vel Minus Cognitæ ex Herbario Horti Thenensis." The first part bears date March, 1904.

An account of the Harvard Botanical Station in Cuba, with extracts from Superintendent Grey's report, is given by Dr. Goodale in *The American Journal of Science* for July.

A quarto treatise on the Phytoplankton of the Atlantic and its tributaries, by P. T. Cleve, is published by the author at Upsala.

A large number of economic topics are well treated by Halsted in his recently issued *Report of the Botanical Department* of the New Jersey Agricultural Experiment Station, for 1903.

An account of the principal commercial plant fibers, by Dewey, is separately printed from the *Yearbook* of the U. S. Department of Agriculture, for 1903.

An illustrated account of some old trees, by Pollmer, is contained in *Die Gartenwelt* of June 25.

Professor Peck's Report of the State Botanist for 1903, published as Bulletin 75 of the New York State Museum, contains among other things a paper on edible fungi and one on the species of Cratægus found in the State.

Experiments in the heredity of peas are detailed by Hurst in the *Journal of the Royal Horticultural Society* of May.

A second edition of E. G. Paris' "Index Bryologicus," reaching to the end of 1900, is being issued in fascicles from the Hermann Press, of Paris.

A further addition to the nomenclature literature to be laid before the Vienna Congress of 1905, by Harms, forms appendix 13 to the current *Notizblatt des K. botanischen Gartens und Museums zu Berlin*, and is dated June 20, 1904.

A bacterial rot of the Calla is described by Townsend in *Bulletin No. 60* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

An account of "fungoid pests of the garden," by Cooke, is contained in current numbers of the *Journal of the Royal Horticultural Society*.

Cultural experiments with biologic forms of the Erysiphaceæ are detailed by Salmon in a paper separately printed from the *Philosophical Transactions of the Royal Society of London*, Series B, vol. 197.

"Investigations of Rusts" is the title of *Bulletin No. 63* of the Bureau of Plant Industry of the U. S. Department of Agriculture, by Carleton.

A paper by Cooke on edible fungi is contained in the *Journal of the Royal Horticultural Society* of May.

The botanical articles of greatest interest in the *Year-book of the United States Department of Agriculture* for 1903 are: — Kebler, "The Adulteration of Drugs"; Taylor, "Promising New Fruits"; Shepard, "Macaroni Wheat"; True, "Cultivation of Drug Plants in the United States"; Dewey, "Principal Commercial Fibers"; and the reports on plant diseases forming part of the appendix.

Vol. 11 of the *Proceedings of the Iowa Academy of Sciences* contains the following articles of botanical interest: — Buchanan, "A Contribution to our Knowledge of the Development of *Prunus Americana*"; Miller, "The Lichen Flora of the 'Ledges,' Boone County, Iowa"; Martin, "A Chemical Study of *Rhus glabra*"; Cratty, "The Flora of Emmet County"; and Mueller, "A Preliminary List of the Flowering Plants of Madison County."

A number of interesting botanical papers are contained in the recently issued Vol. 36 of the *Transactions and Proceedings of the New Zealand Institute.*

Vol. 1 of Rendle's "Classification of Flowering Plants" (Cambridge, 1904) deals with Gymnosperms and Monocotyledons.

An account of Pæonia, as now popularly cultivated, is contributed by Miller to *Country Life in America* for September.

The first part of a discussion of the variability of Eucalyptus under cultivation is published by Maiden in No. 112 of the *Proceedings of the Linnean Society of New South Wales.*

An illustrated account of the cultivation of *Acacia mollissima*, by Fairchild, forms *Bulletin no. 51, part 4* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

Vol. 10, part 1, of the *Annals of the Royal Botanic Garden, Calcutta*, consists of a revision of the species of Dalbergia of S. E. Asia, by Prain.

Opuntia rutila is figured in the *Monatsschrift für Kakteenkunde* of July 10.

Ailantus Vilmoriniana, a Chinese species, recently introduced into France, is described and figured by Dode in the *Revue Horticole* of Sept. 16.

Two segregates of *Rubus argutus Randii* are described by Blanchard in *The American Botanist* of July.

A very large tree of *Quercus alba* is described and figured by Rothrock in *Forest Leaves* for August.

The fruit of Melocanna, a viviparous grass without endosperm, is described by Stapf in Vol. 6, part 9, of the current botanical series of *Transactions of the Linnean Society of London.*

An important paper on monœcious and diœcious grasses, with illustrations, is published by Pilger in Engler's *Botanische Jahrbücher* of August 16.

The aerating nodal roots of Bambusa are discussed by Montemartini, in Vol. 3, fascicle 2, of the *Contribuzioni alla Biologia Vegetale* of the Palermo botanical institute.

The root structure of North American terrestrial orchids is considered by Holm in *The American Journal of Science* for September.

A study of the Corbularia group of Narcissus is published by Bureau in No. 1–2 of the current volume of the *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France.*

A synopsis of the varieties of pineapple cultivated in Florida is given by Hume and Miller in *Bulletin 70* of the Experiment Station of that State.

No. 23 of Holm's "Studies in the Cyperaceæ," published in *The American Journal of Science* for October, deals with morphological aspects of the inflorescence.

No. 2 of *Plantæ Novæ vel Minus Cognitæ ex Herbario Horti Thenensis*, dated in June last, contains a considerable number of Cyperaceæ by Clarke.

An exhaustive paper entitled "Contributions to the Knowledge of the Life History of Pinus with Special Reference to Sporogenesis, the Development of the Gametophytes and Fertilization," by Miss Ferguson, forms a thick brochure of Vol. 6 of the *Proceedings of the Washington Academy of Sciences*, issued on October 4th.

In the *Gardeners' Chronicle* of August 6, Mr. Shaw restores two lost names of Morelet (1855) for later names in Pinus by Grisebach and himself.

A general account of the vegetation of Missouri, by Duggar, is contained in Williams' "The State of Missouri," printed at Columbia, Mo.

A physiographic and ecological study of the Lake Eagle region of Indiana, by Mills, is contained in the 28th *Annual Report* of the Department of Geology and Natural Resources of that State.

Separates of Dr. Kennedy's "Flora of Willoughby, Vt.," have been issued, in attractive binding, by the author, from *Rhodora.*

An account of the flora of the Peace River region of Canada, is given by Macoun in *The Ottawa Naturalist* of September.

Botanical items are included in Notes on the Falkland Islands, by Vallentin, in Vol. 48, part 3, of the *Memoirs and Proceedings of the Manchester Literary and Philosophical Society*, issued in July last.

A "Novus Conspectus Floræ Europæ," by Gandoger, is in course of publication in the *Bulletin de l'Académie Internationale de Géographie Botanique.*

Ascherson and Græbner's "Synopsis der Mitteleuropäischen Flora," in Lieferung 31–2 concludes the Spathifloræ.

Coste's "Flore descriptive et illustrée de la France, etc.," in Vol. 3, fascicle 2 reaches into Polygonaceæ.

The concluding third volume of Halácsy's "Conspectus Floræ Græcæ," has recently been issued from the Engelmann press of Leipzig.

Vol. 4, section 2, part 2, of the "Flora Capensis," under the editorship of Sir William T. Thiselton-Dyer, is occupied with Scrophulariaceæ.

Cooke's "Flora of the Presidency of Bombay," in Vol. 2, part 1, reaches well into Boraginaceæ, — on the Bentham and Hooker sequence of families.

An account of the vegetation of the district of Minbu, in Upper Burma, by Gage, forms Vol. 3, part 1, of the *Records of the Botanical Survey of India.*

A comprehensive biological account of the island of La Mocha, by Reiche and others, forms No. 16 of the *Anales del Museo Nacional de Chile.*

Notes by Bessey in *Science* of July 22 show that each plumed akene of Taraxacum weighs on an average .00044 gm., and that a medium sized tree of *Populus deltoides* bears not far from 28,000,000 seeds, of an average weight of .00065 gm. each.

An interesting paper on the adventitious epiphytic occurrence of terrestrial plants in Norway has been distributed by Holmboe from No. 6 of the current volume of the *Christiania Videnskabs-Selskabs Forhandlingar.*

The thermotropism of Rhododendron is described and illustrated by Johnson in *Country Life in America* for November.

A preliminary paper on electrotropism of roots, by Plowman, is published in *The American Journal of Science* for August and September.

A popular account of carnivorous plants, by Shreve, is contained in *The Popular Science Monthly* for September.

A new and enlarged edition of Pammel's "Flower Ecology" has been published from the J. B. Hungerford Press of Carroll, Iowa, under the title "Ecology." Seventeen chapters deal with the chief topics.

Professor Kraemer has issued separates of a paper on the origin and nature of color in plants from Vol. 43 of the *Proceedings of the American Philosophical Society.*

A note on the pollination of *Calepogon pulchellus* is published by Klugh in *The Ottawa Naturalist* of August.

A syllabus of the economic plants of the temperate zones represented in the Dahlem garden is given by Engler in Appendix 14 of the *Notizblatt des K. botanischen Gartens und Museums zu Berlin.*

A key to the genera of the forest trees of Indiana, based chiefly upon leaf characters, by Coulter and Dorner, has been issued by the authors from Lafayette, Ind.

Under the title "Getting Acquainted with the Trees," a tasty and beautifully illustrated little book by McFarland has recently been issued by The Outlook Company, of New York.

An excellent little illustrated pocket guide to British trees is Step's "Wayside and Woodland Trees" (Warne, London and New York, 1904).

Stone's "Timbers of Commerce and their Identification" (Rider, London, 1904) is a descriptive catalogue — rather than handbook — of 247 species, with phototype illustrations of the wood sections.

The forest resources of Texas are discussed by Bray in *Bulletin 47* of the Bureau of Forestry, U. S. Department of Agriculture; and the forests of the Hawaiian Islands are discussed by Hall in *Bulletin 48* of the same Bureau.

"The Forest Manual," containing the Forest Act (No. 1148), extracts from other laws of the Philippine Commission relating to the forest service, and the forest regulations prepared in accordance with the provisions of the Forest Act, is a little pamphlet recently issued by the insular Bureau of Forestry.

An account of basket willows and their insects is given by Hubbard and Chittenden in *Bulletin No. 46* of the Bureau of Forestry, U. S. Department of Agriculture.

The chestnut in southern Maryland is discussed by Zon in *Bulletin No. 53* of the Bureau of Forestry of the U. S. Department of Agriculture.

Hooper reports on Indian gums yielded by species of Acacia in *The Indian Forester* of September.

A considerable account of Gutta Percha and Rubber is contained, with illustrations, in the recently issued *Report of the Superintendent of Government Laboratories in the Philippine Islands*, for the year ending Sept. 1, 1903.

Economic articles on the Sisal plants and the West Indian anthracnose of cotton [caused by *Colletotrichum Gossypii Barbadense*] are contained in Vol. 5, no. 2, of the *West Indian Bulletin.*

An account of the propagation and marketing of Oranges in Porto Rico is given by Hendricksen in *Bulletin No. 4* of the Porto Rico Agricultural Experiment Station.

An account of the anatomy of edible berries, by Winton, is published in the *American Journal of Pharmacy* for September.

Native ornamental plants of New Mexico are considered by

Wooton in *Bulletin No. 51* of the New Mexico Agricultural Experiment Station.

Nestler, in a pamphlet on "Hautreizende Primeln" (Berlin, Borntraeger, 1904), shows that *Primula Sinensis*, *P. Sieboldii* and *P. Cortusoides* have the poisonous properties now well known as possessed by *P. obconica*, which he finds not shared by *P. officinalis*, *P. megaseæfolia*, *P. floribunda*, *P. Auricula*, *P. capitata*, *P. farinosa*, *P. Japonica*, *P. hirsuta*, *P. Clusiana*, *P. minima* or *P. rosea*.

The cultivation of mushrooms, including the "tissue-culture" growth of spawn, is considered by Duggar in *Farmers' Bulletin No. 204* of the U. S. Department of Agriculture.

An important paper on sexual reproduction in the Mucorineæ, by Blakeslee, forming No. 58 of the "Contributions from the Cryptogamic Laboratory of Harvard University," is published as Vol. 40, no. 4, of the *Proceedings of the American Academy of Arts and Sciences*.

Nos. 15 to 18 of Lloyd's *Mycological Notes* deal mainly with puffballs, especially the typical material of European and North American herbaria.

An article on Uredineæ, with far-reaching conclusions on sexuality, by Blackman, is published in the *Annals of Botany* for July.

An account of *Bacillus violaceus Manilæ*, a pathogenic species, is given by Woolley in *Publication 15* of the Bureau of Government Laboratories of Manila.

An account of *Coniothyrium Diplodiella* is given by Montemartini in *L'Italia Agricola* of September 30.

Conidial fruit of Morchella, similar to if not identical with *Costantinella cristata*, is described by Molliard in the *Revue générale de Botanique* of June 15.

Three fascicles of Lindau's account of Hyphomycetes ("Rabenhorst's Kryptogamen-Flora von Deutschland etc., Vol. 1, Abtheilung 8") have recently appeared.

A continuation of Rehm's "Ascomycetes Americæ Borealis" is contained in the July number of *Annales Mycologici*.

Diseases of Ginseng are discussed by Van Hook in *Bulletin 219* of the Cornell University Agricultural Experiment Station, issued in June.

An excellent series of folio views in the Botanic Garden at Brussels has recently been issued by the Ministère de l'Agriculture of Belgium.

A portrait of Sir Joseph Hooker is published in Vol. 6, part 3, of the *Transactions of the Natural History Society of Glasgow.*

A medallion portrait of A. P. de Candolle forms the frontispiece of Vol. 4, no. 8, of the *Bulletin de l'Herbier Boissier.*

The Journals.—*Journal of Mycology*, May: — Morgan, "*Tubercularia fasciculata*"; Smith, "A New Egg-Plant Fungus [*Ascochyta Lycopersici*]"; Durand, "Three New Species of Discomycetes"; Christman, "Variability in our Common Species of Dictyophora"; Cockerell, "A New Hypholoma"; Clements, "Saccardo, De Diagnostica et Nomenclatura Mycologica, Admonita Quædam"; Kellerman, "A New Species of Næmosphœra [*N. lactucicola*]"; Kellerman, "Minor Mycological Notes — IV"; Kellerman, "Index to North American Mycology" [continued]; Kellerman, "Elementary Mycology" [continued]; Kellerman and Ricker, "New Genera and Species of Fungi Published since the year 1900"; and Kellerman, "Notes from Mycological Literature — X."

Botanical Gazette, June: — Thaxter, "Notes on the Myxobacteriaceæ"; Smith, "Undescribed Plants from Guatemala and other Central American Republics — XXVI"; Kearney, "Are Plants of Sea Beaches and Dunes true Halophytes?"; Eastwood, "Some New Species of Western Polemoniaceæ"; Peirce, "Notes on the Monterey Pine"; Chrysler, "Anatomical Notes on Certain Strand Plants"; and Allen, "Chromosome Reduction in *Lilium Canadense.*"

Botanical Gazette, July: — Land, "Spermatogenesis and Oogenesis in *Ephedra trifurca*"; Smith, "Water-Relation of *Puccinia Asparagi*"; MacDougal, "Delta and Desert Vegetation"; Arthur, "The Æcidium of Maize Rust"; Livingston and Jensen, "An Experiment on the Relation of Soil Physics to Plant Growth"; and Eastwood, "A New Gilia."

The Bryologist, July: — Fink, "Further Notes on Cladonias — III"; Britton, E. G., "Further Notes on Sematophyllum"; Gilbert, "Mounting Mosses"; and Grout, "*Tortula pagorum* in Georgia."

Bulletin of the Torrey Botanical Club, June: — Salmon, "A Revision of some Species of Ectropothecium"; Murrill, "The Polypora-

ceæ of North America — VII"; Cook, "The Nomenclature of the Royal Palms"; and Osterhout, "Notes on Colorado Plants."

Journal of Mycology, July: — Morgan, "New Species of Pyrenomycetes"; Holway, "Notes on Uredineæ — II"; Ricker, "Notes on Fungi — I, New or Interesting American Uredineæ"; Ellis and Everhart, "New Species of Fungi from Various Localities"; Kellerman, "A New Species of Peronospora"; Kellerman, "Cultures of Puccinia Thompsonii"; Kellerman, "Elementary Mycology" (continued); Kellerman, "Index to North American Mycology" (continued); Kellerman, "Notes from Mycological Literature — XI"; and Kellerman and Ricker, "New Genera of Fungi Published since the Year 1900" (continued).

Journal of the New York Botanical Garden, July: — Britton, "Explorations in Florida and the Bahamas"; Nash, "Effects of the Past Winter on Shrubs."

Ohio Naturalist, June: — York, "The Embryo-Sac and Embryo of Nelumbo; Kellerman and Jennings, "Flora of Cedar Point"; Kellerman, "Flora of Hen and Chicken Islands, 1903"; and Schaffner, "The Jacket Layer in Sassafras."

The Plant World, June: —Nehrling, "The Beginning of Spring in Florida — III"; Safford, "Extracts from the Note-Book of a Naturalist on the Island of Guam — XIX"; Schofield, "The Glumes of 'Beardless' Barley"; and Barrett, "The Lleren, a Rare Root Crop."

The Plant World, July: — Safford, "Extracts from the Note-Book of a Naturalist on the Island of Guam — XX"; Goetting, "On Lonely Rocks and Sand-edged Bluffs"; Shear, "The Black Fungi"; and Bailey, "Some Unusual Woody Plants."

Rhodora, June: — Kennedy, "Flora of Willoughby, Vermont"; Fernald, "Identity of Michaux's *Lycopus uniflorus*"; Eggleston, "Addenda to the Flora of Vermont"; Hervey, "Plants New to the Flora of New Bedford"; Collins, "Some Maine Mosses"; Sheldon, "Some Introduced Weeds of Connecticut"; Robinson, "James Lawrence Bennett"; Knight, "A New Sunflower for Maine"; and Kennedy, "Additional Notes from Willoughby."

Rhodora, July: — Collins, "Some Interesting Rhode Island Bogs"; Deane, "Preliminary Lists of New England Plants — XVII [Polemoniaceæ — Acanthaceæ]"; Fernald, "The Green Alders of New England"; Clark, "An Interesting Specimen of *Arisæma tri-*

phyllum"; and Parlin, "A New Station for *Nyssa sylvatica* in Maine."

Torreya, June: — Campbell, "Resistance of Drought by Liverworts"; Lloyd, "The Pollen Tube in the Cucurbitaceæ and Rubiaceæ"; MacDougal, "Evening Primroses"; Berry, "Teratology of Seedling Bean"; and Britton, "*Scirpus Coloradœnsis* sp. nov."

Torreya, July: — Jelliffe, "Additions to 'The Flora of Long Island'"; Nash, "A Collecting Trip to Haiti"; Berry, "Two-bracted Dogwood"; Britton, "*Savia Bahamensis*, n. sp.; and Shafer, "Notes on Cuban Plants."

Botanical Gazette, August: — Davis, "Oogenesis in Vaucheria"; Billings, "A Study of *Tillandsia usneoides*"; Spalding, "Biological Relations of certain Desert Shrubs. 1, The Creosote Bush (*Covillea tridentata*) in its Relation to Water Supply"; Hitchcock, "Notes on North American Grasses — III"; Perkins, "Carl Schumann" (with portrait); Chamberlain, "A Correction."

The Botanical Gazette, for September: — Chrysler, "Development of the Central Cylinder of Araceæ and Liliaceæ"; Johnson, "Development and Relationship of Monoclea"; Coker, "On the Spores of Certain Coniferæ"; Peirce, "Artificial Parasitism"; and Herre, "Growth of *Ramalina reticulata*."

The Botanical Gazette, October: — Davis, "The Relationships of Sexual Organs in Plants"; Fink, "A Lichen Society of a Sandstone Riprap"; Bergen, "Transpiration of Sun Leaves and Shade Leaves of *Olea Europœa* and other broad leaved Evergreens"; Hitchcock, "Notes on North American Grasses — IV"; Stevens, "Oogenesis and Fertilization in *Albugo Ipomœæ-Panduratæ*."

The Bryologist, September: — Britton, "Hyophila, a New Genus to the United States"; Harris, "Lichens — Stereocaulon, Pilophorus and Thamnolia"; Clarke, "Curbstone Mosses."

Bulletin of the Torrey Botanical Club, July: — Gruenberg and Gies, "Chemical Notes on Bastard Logwood"; Bicknell, "Studies in Sisyrinchium — X, The Species of California"; Cushman, "Notes on Micrasterias from Southeastern Mass."; Rydberg, "Studies on the Rocky Mountain Flora — XI."

Bulletin of the Torrey Botanical Club, August: — Murrill, "Polyporaceæ of North America"; Shaw, "Note on the Sexual Generation and the Development of the Seed-Coats in Certain of the Papavera-

ceæ"; Cannon, "Observations on the Germination of *Phoradendron villosum* and *P. Californicum*"; Griggs, "Two New Species of American Wild Bananas, with a Revision of the Generic Name."

Bulletin of the Torrey Botanical Club, September: —Vail, "Studies in the Asclepiadaceæ—VIII"; Cockerell, "North American Species of Hymenoxys."

The Fern Bulletin, July: — Price, "Contribution toward the Fern Flora of Kentucky"; Clute, "The Star Fern"; Prince, "Some Ferns of the Cave Region of Stone County, Mo."; Eaton, "The California Gold Fern"; Clute, "A New Form of the Christmas Fern"; Eaton, "Is *Asplenium lanceum* American?"; House, "Some Rare Ferns of Central New Jersey"; Parish, "Additions to the California Fern Flora"; Clute, "Raising Prothallia of Botrychium and Lycopodium"; Clute, "Concerning Forms and Hybrids"; Eaton, "*Isoetes Amesii*, a Correction"; Osmun, "*Equisetum variegatum* in Connecticut."

Journal of Mycology, September: – "Benjamin Matlack Everhart, Obituary" [with portrait]; Morgan, "Pyrenomycetes Scarcely Known in North America"; Holway, "Notes on Uredineæ — III"; Fairman, "Some New Fungi from Western New York"; Ellis and Kellerman, "A New Phyllachora from Mexico"; Kellerman and Ricker, "New Genera of Fungi published since the year 1900" (continued); Kellerman, "Index to North American Mycology" (continued); Kellerman, "Notes from Mycological Literature—XII."

Journal of the New York Botanical Garden, August: — Small, "Report upon Further Exploration of Southern Florida"; Howe, "Collections of Marine Algæ from Florida and the Bahamas."

Journal of the New York Botanical Garden, September: — Lloyd, "A Visit to the Desert Botanical Laboratory"; Nash, "An Agave [*A. Palmeri*] in Flower."

Journal of the New York Botanical Garden, October: — Robinson, "A Visit to the Botanical Laboratory at Cinchona, Jamaica"; Nash, "The Palms of Florida."

Muhlenbergia, No. 5: — Heller, "The Genus Ribes in California; Western Species, New and Old — III."

The Plant World, September: — Safford, "Extracts from the Note-Book of a Naturalist on the Island of Guam"; Fitzpatrick, "The June Flora of the Ocbeyedan Mound"; Waters, "Geotropism of

Polyporus"; Barrett, "The Guapa, an Egregious Economic"; de Vries, "The Method of Experimentation upon the Origin of Species."

Rhodora, August: — Evans, "Notes on New England Hepaticæ — II"; Bicknell, "*Juncus aristulatus* in New England"; Clark, "Notes on Maryland Plants"; Woodward, "Notes on Two Connecticut Grasses"; Fernald, "*Pyrola asarifolia* Michx., var. *incarnata*, n. comb."; Clark, "*Triosteum perfoliatum* in Mass."; and Driggs, "The Connecticut Flora at the St. Louis Exposition."

Rhodora, September: — Collins, "A Sailor's Collection of Algæ"; Graves, "An Undescribed Variety of Goldenrod"; Deane, "Note on *Hydrophyllum Canadense*"; Evans, "Notes on the New England Hepaticæ — II"; Fernald, "The Identity of Andersson's *Salix pellita*"; Chamberlain, "New Stations for Maine Plants"; and Graves, "Some Unusual Connecticut Plants."

Torreya, August: — Banker, "Notes on the Variability of *Hypothele repanda*"; Nash, "The Botanical Meeting at McCall's Ferry, Pa."; Barnhart, "The Nomenclature of Hexalectris and Aplectrum"; Nash, "The Validity of the Genus Paratheria"; Harper, "*Sarracenia flava* in Virginia"; Britton, "An Undescribed Species of Alnus."

Torreya, September: — Bicknell, "Three New Violets from Long Island"; Barnhart, "The Date of Pursh's 'Flora'"; C. B. Robinson, "The Ferns of Northern Cape Breton"; Harper, "The Type-Locality of *Arenaria brevifolia*"; Murrill, "A New Polyporoid Genus [Phylloporia] from South America"; Britton, "A New Species of Bradburya — *B. Floridana*"; and Berry, "Rings in Bark formed by Branches."

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

BENEDIKT, M. El. Biomecanismo o neovitalismo en Medicina y en Biologia. Traducida par. A. L. Herrera. Mexico, Americana Librera é Impresora, 1904. 8vo, 92 pp., 32 figs.— BÜGERSTEIN, A. Die Transpiration der Pflanzen. Eine physiologische Monographie. Jena, Fischer, 1904. 8vo, x + 283 pp., 24 figs., 7 marks.— CARTER, M. H. Nature Study with Common Things. An Elementary Laboratory Manual. New York, American Book Co., 1904. 8vo, 150 pp., illustrated.— DAVENPORT, C. B. Statistical Methods with Special Reference to Biological Variation. Second revised edition. New York, John Wiley & Sons, 1904. 12mo, viii + 223 pp., figs., diags. & tables.— DRIESCH, H. Naturberichte und Natururteile. Analytische Untersuchungen zur reinen und emperischen Naturwissenschaft. Leipzig, Engelmann, 1904. 8vo, viii + 239 pp. 4 marks.— EASTMAN, HELEN. New England Ferns and their Common Allies. An Easy Method of determining the Species. Boston, Houghton, Mifflin Co., 1904. 8vo, xix + 161 pp., illustrated — FEDDE, F. Literatur der Morphologie und Systematik der Phanerogamen vom Jahre 1903. Berlin, Bornträger, 1904. 8vo, 713 pp.— GASSER, H. The Law of Atomic Weight and Law of Gravitation. Plattsville, Wis., 1904. 8vo, 39 pp.— GARDINER, J. S. The Fauna and Geography of the Maldive and Laccadive Archipelagoes, etc. Vol. ii, Pt. iii, pp. 699–805, pls. 49–66.— GOFF, E. S. and MAYNE, D. D. First Principles of Agriculture. New York, American Book Co., 1904. 8vo, 248 pp., 7 colored pls. and 141 text figs.— HABERLANDT, G. Physiologische Pflanzenphysiologie. Dritte Auflage. Leipzig, Engelmann, 1904. 8vo, xvi + 616 pp., 264 figs. 18 marks.— HALL, E. H. College Laboratory Manual of Physics. New York, Henry Holt & Co., 1904. 8vo, viii + 138 pp., 62 figs.— INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE. N. ZOOLOGY. Pts. i–ii Author's and Subject Catalogues. London, Harrison & Sons, 1904. 8vo, xv + 1528 pp. 37/6.— LLOYD, F. E. and BIGELOW, M. A. The Teaching of Biology in the Secondary Schools. American Teacher's Series. New York, Longmans, 1904. 8vo, viii + 491 pp.— MATHEWS, F. S. Field Book of Wild Birds and their Music. A Description of the Character and Music of Birds, intended to assist in the Identification of Species common in the Eastern United States. New York, Putnams, 1904. 8vo, xxxv + 262 pp., illustrated.— PAX, F. Prantles Lehrbuch der Botanik. Zwölfte verbesserte und vermehrte Auflage. Leipzig, Engelmann, 1904. 8vo, viii + 478 pp., 438 figs. 6 marks. — PRENANT A., BRUIN, P. and MAILLARD, L. Traité d. Histologie. Tome I. Cytologie générale et spéciale. Paris, Reinwald, 1904. 8vo, xxxii + 277 pp., 191 figs. — STONE, H. The Timbers of Commerce and their Identification. London, William Rider & Son, 1904. 8vo, xxxviii + 311 pp., 22 photo. pls.— TROUESSART, E. L. Catalogus Mammalium tam viventium quam fossilium Quinquennale Supplementum, anno 1904. Fasc. I–II. Primates, Prosimiæ, Chiroptera, Insectivora, Carnivora, Pinnipedia, Rodentia. Berlin, Friedlænder,

1904. 8vo, iv + 546 pp. 24 marks.— WEST, G. S. A Treatise on the British Freshwater Algæ, Cambridge Biological Series. Cambridge, University Press, 1904. 8vo, xvi + 372 pp., 167 figs.— WEST, W. and WEST, G. S. A Monograph of the British Desmidiaceæ. Vol. i. London, Printed for the Ray Society, 1904. 8vo, xxxvi pp. + 224, 32 pls.

AMES, O. Three New Orchid Species. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 119-120.— AMES, O. Additions to the Orchid Flora of Florida. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 115–118.— BAKER, F. C. The Molluscan Fauna of the Dells of Wisconsin. *Trans. Acad. Sci. St. Louis.* Vol. xiv, No. 2, pp. 99–105.— BAKER, F. C. Notes on Planorbis truncatus Miles. *Trans. Acad. Sci. St. Louis.* Vol. xiv, No. 3, pp. 107–110.— BANCROFT, F. W. Æstivation of Botrylloides gascoi Della Valle. *Mark Anniversary Vol.* Pp. 147–166, pl. 11.— BANGS, O. Two New Subspecies of Tropical American Tyrant Birds. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 113–114.— BANKS, N. A Treatise on the Acarina or Mites. *Proc. U. S. Natl. Mus.* Vol. xxviii, pp. 1–114, 201 figs.— BENNETT, MARY E. Are Roots Aerotropic? *Bot. Gaz.* Vol. xxxvii, pp. 241–259, 5 figs.— BOWNOCKER, J. A. The Occurrence and Exploitation of Petrolium and Natural Gas in Ohio. *Bull. Geol. Surv. Ohio.* Ser. iv, No. 1, 325 pp., maps.— BRAY, W. L. Forest Resources of Texas. U. S. Dept. Agr., *Bull. Bur. Forestry.* No. 47, 70 pp., 8 pls.— BRAY, W. L. The Timber of the Edwards Plateau of Texas, etc. U. S. Dept. Agr., *Bull. Bur. Forestry*, No. 49. 30 pp., 5 pls.— BRÖLMANN, H. W. Chilopodes monégasques. *Bull. Mus Oceanogr. Monaco.* No. 15. pp. 15.— BURRITT, C. H. The Coal Measures of the Philippines, etc. *Rept. to U. S. Military Governor in the Philippines.* 269 pp.. maps, etc.— BUSCK, A. Tineid Moths from British Columbia with Descriptions of New Species. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 745–778.— CAUDELL, A. N. Two Orthoptera hitherto unrecorded from the United States. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 949–952.— CHITTENDEN, F. H. Insects Injurious to Basket Willow. U. S. Dept. Agr., *Bull. Bur. Forestry*, No. 46. pp. 63–801. figs. 11–27.— CLARK, H. L. The Echinoderms of the Wood's Hole Region. *Buil. U. S. Fish Comm.* for 1902. pp. 545–576, pls. 1–14.— COCKERELL, T. D. A. Notes on Tetraneuris linearifola. *Proc. Biol. Soc. Wash.* Vol. xvii, pp 111–112.— DOWLING, D. B. Report on an Exploration of Ekwan River, Sutton Mill Lakes and Part of the West Coast of James Bay. Ann. *Rept. Geol. Surv. Canada.* Vol. xiv, 60 pp., 2 pls., 7 figs.— DYAR, H. G. The Lepidoptera of the Kootenai District of British Columbia. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 779–938.— ELLIOT, D. G. The Land and Sea Mammals of Middle America and the West Indies. *Field Columb. Mus. Publ.*, Zool. Ser. Vol. iv, Pts. i–ii, xx + xlix + 850 pp., 68 pls. & 329 text figs.— EVANS, H. M. A New Cestraciont Spine from the Lower Triassic of Idaho. *Univ. Cal. Publ., Bull. Dept. Geol.* Vol. iii, No. 18, pp. 397–402, pl. 47.— FARRINGTON, O. C. Observations on the Geology and Geography of Western Mexico including an Account of Cerro Mountain. *Publ. Field Columb. Mus.*, Geol. Vol. ii, pp. 197–228, pls. 55–70, map and 4 figs.— FELDT, E. P. and JRUKEL, L. H. Monograph of the Genus Saperda. *Bull. N. Y. State Mus.* No. 74. 86 pp., 14 pls.— FERGUSON, MARGARET. Contributions to the Knowledge of the Life History of Pinus with Special Reference to Sporogenesis the Development of the Gametophytes and Fertilization. *Proc. Wash. Acad. Sci.* Vol. vi, pp. 1–202, pls. 1–24.— FOSTER, E. Notes on the Free Swimming Copepods of the Waters in the Vicinity of the Gulf Biologic Station Louisiana.

Second Rept. Gulf Biol. Sta. pp. 67–79.— GIRTY, G. H. New Molluscan Genera from the Carboniferous. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 721–736, pls. 45–47.— HARRISS, W. P. and C. W. Lichens and Mosses of Montana. *Bull. Univ. Mont.* No. 19, pp. 313–330, pls. 58–64.— HERRERA, A. L. La Citogénesis Experimental y ea Oftamologia. *Ann. de Oftamologia.* Tom. 4, pp. 425–429, 2 figs.— HOLDEN, P. G. Selecting and Preparing Seed Corn. *Bull. Iowa. Agr. Exp. Sta.*, No. 77. pp. 169–334, 47 figs.— HOUSER, G. L. The Animal Cell in the Light of Recent Work. *Proc. Iowa. Acad. Sci.* Vol. xi, pp. 39–53.— HUBBARD, W. F. The Basket Willow. U. S. Dept. Agr., *Bull. Bur. Forestry*, No. 46. 61 pp., 7 pls.— IJIMA, I. Studies on the Hexactinellida. Contribution IV. (Rosselidæ). *Jour. Coll. Sci. Imp. Univ. Tokyo.* Vol. xviii, 307 pp., 23 pls. — ILLINOIS STATE LABORATORY OF NATURAL HISTORY. Studies of the Food of Birds, Insects, and Fishes. Second Edition. *Bull. Ill. State Lab. Nat. Hist.* Vol. i, No. 3, 176 pp. JENNINGS, H. S. Asymmetry in Certain Lower Organisms and its Biological Significance. *Mark Anniversary Vol.* pp. 315–337.— JORDAN, D. S. and SNYDER, J. O. Notes on Collections of Fishes from Oahu Island and Laysan Island, Hawaii with Descriptions of Four New Species. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 939–948.— JORDAN, D. S. and SNYDER, J. O. Description of a New Species of Fish (Apogon evermanni) from the Hawaiian Islands, with Notes on other Species. *Proc. U. S. Natl. Mus.* Vol. xxviii, pp. 123–126.— JUDAY, C. The Diurnal Movement of Plankton Crustacea. *Trans. Wis. Acad. Sci.* Vol. 14, pp. 534–568.— KELLOGG, R. S. Forest Planting in Western Kansas. U. S. Dept. Agr., *Bull Bur. Forestry*, No. 52. 51 pp., 7 pls.— KEMPTON, H. B. The Planting of White Pine in New England. U. S. Dept. Agr., *Bull. Dept. Forestry*, No. 45. 40 pp., 15 pls., 2 figs.— LAMB, L. M. On Dryptosaurus incrassatus (Cope), from the Edmonton Series of the North West Territory. Geol. Surv. Canada, *Contributions to Canadian Palæontology.* Vol. iii, 27 pp., 8 pls. LAMSON-SCRIBNER, F. List of Philippine Agricultural Products and Fiber Plants. *Bull. Bur. Agr. Philip. Ids.* No. 5, 47 pp.— MARSH, C. D. The Plankton of Lake Winnebago and Green Lake. *Bull. Wis. Geol. & Nat. Hist. Surv.* No. 12, vi + 94 pp., 22 pls.— MAXON, W. R. Two New Ferns of the Genus Polypodium, from Jamaica. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 741–744.— MAXON, W. R. A New Fern, Goniophebium pringlei, from Mexico. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 953–954, pl. 48.— MAYER, A. G. Medusæ of the Bahamas. *Mem. Brooklyn Inst. Arts. & Sci.* Vol. i, No. 1, 33 pp., 7 pls.— MCCASKEY, H. D. Report on a Geological Reconnoissance of the Iron Region of Angat Bulucan. *Bull. Manila Mining Bureau.* No. 3, 62 pp., 56 pls., maps.— MCGREGOR, R. C. Notes on Hawaiian Reptiles from the Island of Maui. *Proc. U. S. Natl. Mus.* Vol. xviii. pp. 115–118.— MOENKHAUS, W. J. The Development of the Hybrids between Fundulus heteroclitus and Menidia notata with especial Reference to the Behavior of the Maternal and Paternal Chromatin. *Amer. Jour. Anat.* Vol. iii, pp. 29–65, 4 pls.— MONACO, PRINCE ALBERT DE. Progres de la Biologie Marine. *Butl. Mus. Océanogr. Monaco.* No. 14, pp. 7.— MORGAN, W. C. and TALLMAN, M. C. A Fossil Egg from Arizona. *Univ. Cal. Publ., Bull. Dept. Geol.* Vol. iii, No. 19, pp. 403–410, pls. 48–49.— MORSE, M. Batrachians and Reptiles of Ohio. *Bull. Ohio State Univ.* Ser. 8, No. 18, pp. 96–144, 1 pl., 3 figs.— MERRIAM, C. H. Four New Grasshopper Mice, Genus Onychomus. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 123–126.— MERRIAM, C. H. New and Little Known Kangaroo Rats of the

Genus Peropidus. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 139–146.— MERRIAM C. H. Two New Squirrels of the Aberti Group. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 129–130.— MERRIAM, C. H. Unrecognized Jack Rabbits of the Lepus texianus Group. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 135–138.— MERRIAM, C. H. Jack Rabbits of the Lepus campestris Group. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 131–134.— NEEDHAM, J. G. New Dragon-Fly Nymphs in the United States National Museum. *Proc. U. S. Natl. Mus.* Vol. xvii, pp. 685–720, pls. 38–44.— NELSON, E. W. Descriptions of Seven New Rabbits from Mexico. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 103–110.— NUTTING, C. C. American Hydroids. Part II. The Sertularidæ. *Special Bull. Smith. Inst.* 151 pp., 41 pls.— OBERHOLSER, H. C. Description of Two New Birds from Somali Land. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 737–739.— OSGOOD, W. H. Two New Pocket Mice of the Genus Perognathus. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 127–128.— PEABODY, C. and MOORHEAD, W. K. The Exploration of Jacobs Cavern, McDonald County, Missouri. *Bull. Dept. Archæol. Phillips Acad.* No. 1, 29 pp., map & 11 pls.— RICE, W. N. The Proper Scope of Geological Teaching in the High School and Academy. *Proc. Natl. Educatl. Assoc.* for 1903. pp. 853–856.— RICE, W. N. The Physical Geography and Geology of Connecticut. *Rept. Com. Board Agr.* for 1903. pp. 94–112, map.— RICHARD, J. Campagne scientifique du yacht "Princesse-Alice" en 1903. Observations sur la Sardine, sur le Plankton, sur les Cétacés, sur des filets nouveaux, etc. *Bull. Mus. Oceanogr.* Monaco, No. 11, pp. 29. ROULE, L. La Place des Antipathaires dans la Systematique et la classification des anthozoaires. *Bull. Mus. Oceanogr.* Monaco, No. 16, pp. 3.— SAITO, K. Tieglemella japonica sp. nov. Jour. *Coll. Sci. Imp. Univ. Tokyo.* Vol. xix, 8 pp., 1 pl.— SAITO, K. Uebr das Vorkommen von Saccharomyces anomalous beim Sakebrauen. *Jour. Coll. Sci. Imp. Univ. Tokyo.* Vol. xix, 14 pp., 4 figs.— SANDERS, J. G. Coccidæ of Ohio, I. *Contrib. Dept. Zool. & Ent. Ohio. State Univ.* No. 18, pp. 27–80, 9 pls.— SCHRENK, H. VON. Cross-Tie Forms and Rail Fastenings, with Special Reference to Treated Timbers. U. S. Dept. Agr., *Bull. Bur. Forestry.* No. 50, 70 pp., 71 figs.— SCHRENK, H. VON. Recent Progress in Timber Preservation. *Yearbook U. S. Dept. Agr.* for 1903, pp. 427–440, pls. 53–55.— SINCLAIR, W. J. Euceratherium, a New Ungulate from the Quaternary Caves of California. *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. iii, pp. 411–418, pls. 50–51.— SMITH, E. A. and MCCALLEY. Index to the Mineral Resources of Alabama. *Geol. Surv. Ala.* 79 pp., map and figs.— SMITH, H. M. Description of a New Species of Blind Eel of the Genus Anguilla. *Proc. Biol. Soc. Wash.* Vol. xvii, pp. 121–122, 1 fig. STEVENSON, W. H. and CHRISTIE, J. L. Draining Conditions in Iowa. *Bull. Iowa Agr. Exp. Sta.* No. 78, pp. 239–263, 4 figs.— STEWART, J. H. and HITE, B. H. Commercial Fertilizers. *Bull. Va. Agr. Exp. Sta.* No. 92, 59 pp.— TASSIN, W. The Persimmon Creek Meteorite. *Proc. U. S. Natl. Mus.* Vol. xxvii, pp. 955–959, pls. 49–50.— THOULET, J. Mesures des courants marines au moyen de l' analyse physique et chimique d'enchantillons d'eaux récoltés en séries. *Bull. Mus. Oceanogr. Monaco.* No. 12, pp. 8.— TOPSENT, E. Sarostegia oculata. Hexactinellides nouvelle des iles du cap-vert. *Bull. Mus. Oceanogr. Monaco.* No. 10, pp. 8, 3 figs.— TOUMEY, J. W. The Relations of Forests to Stream Flow. *Yearbook U. S. Dept. Agr.* for 1903. pp. 279–288. — WARD, H. A. Willamette Meteorite. *Proc. Rochester Acad. Sci.* Vol. x. pp. 137–148, pls. 13–18.— WEBSTER, E. M. Studies of the Habits and Devel-

opment of Neocerata rhodophaga Coquillett. *Bull. Ill. State Lab. Nat. Hist.* Vol. vii, pp. 15–25, pl. 3.— WEBSTER, F. M. Studies of the Life History, Habits, and Taxonomic Relations of a New Species of Oberea (Oberea ulmicola Chittenden). *Bull. Ill. State Lab. Nat. Hist.* Vol. vii, pp. 1–14, pls. 1–2.— WEIDMAN, S. The Barboo Iron-Bearing District of Wisconsin. *Bull. Wis. Geol. and Nat. Hist. Surv.* No. 13, x + 190 pp., 23 pls.— WEIDMAN, S. Preliminary Report on the Soils and Agricultural Conditions of Central Wisconsin. *Bull. Wis. Geol. & Nat. Hist. Surv.* No. 11, 68 pp., 10 pls. & map.— WOOTON, E. O. Native Ornamental Plants of New Mexico. *Bull. N. Mex. Agr. Exp. Sta.* No. 51, 40 pp., 12 pls.— YENDO, K. A Study of the Genicula of Corallinæ. *Jour. Coll. Sci. Imp. Univ. Tokyo.* Vol. xix, 44 pp., 1 pl.— ZON, R. Chestnut in Southern Maryland. U. S. Dept. Agr. *Bull. Bur. Forestry.* No. 53, 31 pp., 5 pls.

Actes de la Societé Scientifique de Chili. Tom. xii, Liv. 4–5; Tom. xiii, Liv. 1–3.— *Anales del Museo Nacional de Montevideo.* Serie ii, Pt. 1.— *Botanical Gazette*, The. Vol. 37, Nos. 4–6, Vol. 38, Nos. 1–3.— *Bulletin of the Johns Hopkins Hospital.* Vol. 15, Nos. 157–163.— *Bulletin du Musée Océanographique de Monaco.* Nos. 13 and 17.— *Condor*, The. Vol. 6, Nos. 3–4.— *Higher Science*, May.— *Journal Cincinnati Society of Natural History.* Vol. xx, No. 4.— *Journal of Geology*, The. Vol. 12, No. 4.— *National Geographic Magazine*, The. Vol. xv, No. 7.— *Notarisia, La Nuova.* Ser. 15, Apr. and July.— *Periodische Blätter für Realienunterricht und Lehrmittelwesen.* Jahrg. viii, Heft 2.— *Proceedings of the Iowa Academy of Sciences* for 1903. Vol. xi, 282 pp., 15 pls. *Proceedings of the Natural Science Association of Staten Island.* Vol. ix, Nos. 5–7.— *Proceedings of the Rhodesia Scientific Association.* Vols. i–iii, 1899–1902. *Proceedings South London Entomological and Natural History Society* for 1903. 90 pp., 1 pl., 1 chart.— *Report of the U. S. Fish Commission* for the year ending June 30, 1903. 138 pp.— *Réveil Salicole, Ostreicole et des Pêches Maritimes.* Ann. iii, Nos. 28–29. *Spelunca.* Tom. v, No. 36.— *Verhandlung des deutschen wissenschaftlichen Vereins zu Santiago de Chili.* Bd. iv, Heft. 6, Bd. v, Heft. 1.

(*No. 454 was issued Nov. 26, 1904.*)

VOL. XXXVIII, NO. 445 JANUARY, 1904

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

INDIANAPOLIS MAR 25 1904 LIBRARY

CONTENTS

		Page
I.	Adaptations to Aquatic, Arboreal, Fossorial and Cursorial Habits in Mammals. IV. Cursorial Adaptations . . . RICHARD S. LULL	1
II.	On the Osteology and Systematic Position of the Pygopodes DR. R. W. SHUFELDT	13
III.	The Eruption of Mount Pelee 1851. Translated from the French of LePrieur, Peyraud and Rufz . . . . . DR. T. A. JAGGAR, JR.	51
IV.	Notes and Literature: *Zoology*, Birds in their Relations to Man—	75
	Botany, The Morphology of Angiosperms, Notes	76
V.	Correspondence	88
VI.	Publications Received	89

BOSTON, U. S. A.

GINN & COMPANY, PUBLISHERS

29 BEACON STREET

New York 70 Fifth Avenue | Chicago 378-388 Wabash Avenue | London, W. C. 9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter.

The American Naturalist.

ASSOCIATE EDITORS:

J. A. ALLEN, PH.D., *American Museum of Natural History, New York.*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore.*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville.*
CHARLES E. BEECHER, PH.D., *Yale University, New Haven.*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University.*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca.*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge.*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington.*
D. S. JORDAN, LL.D., *Stanford University.*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley.*
J. G. NEEDHAM, PH.D., *Lake Forest University.*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg.*
D. P. PENHALLOW, S.B., F.R.M.S., *McGill University, Montreal.*
H. M. RICHARDS, S.D., *Columbia University, New York.*
W. E. RITTER, PH.D., *University of California, Berkeley.*
ISRAEL C. RUSSELL, LL.D., *University of Michigan, Ann Arbor.*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington.*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis.*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln.*
WILLIAM M. WHEELER, PH. D., *American Museum of Natural History, New York.*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in Anthropology, General Biology, Zoology, Botany, Paleontology, Geology and Physical Geography, and Mineralogy and Petrography. The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; and in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, critical reviews of recent literature, and a quarterly record of gifts, appointments, retirements, and deaths.

All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to THE AMERICAN NATURALIST, Cambridge, Mass.

All business communications should be sent direct to the publishers.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents.
Foreign subscription, $4.60.

GINN & COMPANY, PUBLISHERS.